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NUREG/CR-7267

Default Parameter Values and Distribution in RESRAD-ONSITE V7.2, RESRAD-BUILD V3.5, and RESRAD-OFFSITE V4.0 Computer Codes

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Manuscript Completed: June 2024
Date Published: June 2024

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ABSTRACT

This report provides updated information on the default parameter values and parameter distributions contained in the RESRAD family of codes since the release of the probabilistic RESRAD-ONSITE Version 6.0 (formerly called RESRAD 6.0), RESRAD-OFFSITE Version 2.0, and RESRAD-BUILD Version 3.0 (Yu et al. 2000, 2007). This report also discusses changes made in the family of RESRAD codes since 2002. All three codes are pathway analysis models designed to evaluate the potential radiological dose incurred by an individual who lives at a site with radioactively contaminated soil or who works in a building containing residual radioactive material.

In this report, probabilistic analyses are performed to evaluate the effect of new parameter values and distributions on radiation exposures associated with common exposure scenarios using new information such as updated dose conversion factors and transfer factors. Based on the probabilistic analyses and the new information available on default parameter values, parameter distributions are either updated if additional data is available or developed if distributions for new parameters are identified. Appendix A of this report provides the default parameter values and parameter distributions for RESRAD-ONSITE Version 7.2, RESRAD-OFFSITE Version 4.0., and RESRAD-BUILD Version 3.5. The exposure scenarios used to evaluate the effect of new parameter values and distributions includes the following: Resident Farmer scenario for the RESRAD-ONSITE code; Building Occupancy scenario for RESRAD-BUILD code; and, Offsite Resident scenario via Water Transport and Offsite Resident scenario via Air Transport for the RESRAD-OFFSITE code. For the RESRAD-ONSITE and RESRAD-BUILD codes, newly developed template files are presented to simulate the Resident Farmer and Building Occupancy scenarios as described in NUREG/CR-5512 (Kennedy and Strenge 1992) and NUREG-1757 (NRC 2006). Appendix B provides the results of the probabilistic analyses for the above exposure scenarios as well as the selection of input parameters, deterministic results and regression analysis for each exposure scenario. Appendix C provides the parameter distributions and supporting information available for use in RESRAD-ONSITE Version 7.2, RESRAD-OFFSITE Version 4.0., and RESRAD-BUILD Version 3.5.

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ACKNOWLEDGMENTS

This work would not have been possible without the technical guidance, feedback, and help of the U.S. Nuclear Regulatory Commission staff from the Office of Nuclear Material Safety and Safeguards and the Office of Nuclear Regulatory Research. Specifically, the authors thank the Dr. Anita Gray, Dr. Stephanie Bush-Goddard, Cyntia Barr and the staff of Argonne National Laboratory.

ABBREVIATIONS

ANL	Argonne National Laboratory
Argonne	Argonne National Laboratory
Bq	Becquerel(s)
°C	degree(s) Celsius
CED	committed effective dose
CEDE	committed effective dose equivalent
CFR	*Code of Federal Regulations*
cm	centimeter(s)
cm^3	cubic centimeter(s)
d	day(s)
DCF	dose conversion factor
DOE	U.S. Department of Energy
ED	effective dose
EPA	U.S. Environmental Protection Agency
ft2	square foot (feet)
g	gram(s)
gal	gallon(s)
GI	gastrointestinal
h	hour(s)
in.	inch(es)
keV	kilo electron volt(s)
kg	kilogram(s)
km^2	square kilometer(s)
L	liter(s)
l	length
l^2	length squared
l^3	length cubed
lb	pound(s)
m	meter(s)
m^2	square meter(s)
m^3	cubic meter(s)
mrem	millirem(s)
NRC	U.S. Nuclear Regulatory Commission
$PM_{2.5}$	fine particulates less than 2.5 microns in diameter
pCi	pico Curie
NOAA	National Oceanic and Atmospheric Administration
SRRC	Standardized rank regression coefficient
TED	total effective dose
yr	year(s)

1 INTRODUCTION

On July 21, 1997, the U.S. Nuclear Regulatory Commission (NRC) published the License Termination Rule (Title 10, *Code of Federal Regulations*, Part 20 [10 CFR 20], Subpart E), which establishes regulatory requirements for nuclear facility licensees that are terminating their licensed operations. The NRC's approach to demonstrating compliance is based on a philosophy of moving from simple, prudently conservative calculations toward more realistic simulations, as necessary, using dose modeling to evaluate exposure to residual radioactivity in soil and structures.

The objective of dose modeling as described in the license termination rule is to assess the total effective dose equivalent (TEDE) to an average member of the critical group from residual contamination, including any contamination that has reached groundwater dependent pathways including, but not limited to ground sources of drinking water. The assessment offers a reasonable translation of residual contamination into estimated radiation doses to the public. Compliance with the NRC-prescribed dose criteria can then be assessed by the modeling results.

As part of the development of site-specific implementation guidance supporting the License Termination Rule and development of a Decommissioning Standard Review Plan, the NRC recognized the need to perform probabilistic analysis with codes that could be used for site-specific modeling.

In 1999, the NRC requested that Argonne modify the RESRAD-ONSITE and RESRAD-BUILD codes for use with the NRC's license termination compliance process and the Decommissioning Standard Review Plan. For this project Argonne developed parameter distribution functions that could be used with the RESRAD-ONSITE, RESRAD-OFFSITE, and RESRAD-BUILD computer codes to perform probabilistic analyses and the necessary computer modules that incorporate the parameter distribution functions for conducting the probabilistic analyses.

Since 2000, the NRC has used probabilistic dose assessment codes to fulfil the agency's need for conducting screening, as well as site-specific and risk-informed radiological impact analysis, to demonstrate compliance with the License Termination Rule (10 CFR Part 20, Subpart E). The codes used by the NRC and its licensees include, but are not limited to, RESRAD-ONSITE, RESRAD-OFFSITE, and RESRAD-BUILD, which together are sometimes referred as part of the RESRAD Family of Codes. The RESRAD-ONSITE and RESRAD-OFFSITE codes compute the release of radionuclides from a source or primary contamination and the subsequent transport through air, groundwater, and surface water pathways to various onsite or offsite locations. RESRAD-BUILD is used to calculate radiological doses resulting from exposure to residual radioactivity in buildings.

The RESRAD-ONSITE code has 130 radionuclide-independent parameters, 10 radionuclide-dependent parameters, and 5 element-dependent parameters. RESRAD-BUILD has 45 radionuclide-independent and 5 radionuclide-dependent parameters. The parameters were classified into three types: physical, behavioral, and metabolic. A strategy was developed to rank the input parameters according to their influence (high, medium, and low) in dose estimation (Yu et al. 2000). Parameter distributions were developed for a total of 66 parameters (45 for RESRAD-ONSITE and 21 for RESRAD-BUILD parameters) that the team identified as having high and medium priority.

Table 1-1 lists the parameters, parameter types, and the assigned distribution types (Table 3-1 in Yu et al. 2000). Some of the parameters for which distributions were developed were classified as the behavioral type. Behavioral parameter values depend on the receptor's behavior and the scenario. For the same group of receptors, a parameter type could change if the scenario undergoes change (e.g., the indoor fraction for recreational use will be different from that found with residential use). The parameter distributions were analyzed tested in the RESRAD-ONSITE code for the Residential Use scenario and in the RESRAD-BUILD code for the Building Occupancy scenario (Kamboj et al. 2000).

Table 1-1 Parameters for Which Probability Density Functions Were Developed in the Past

Parameter	Parameter Type[a]	Assigned Distribution Type
RESRAD-ONSITE /RESRAD-OFFSITE		
Density of contaminated zone (g/cm^3)	P	Normal
Density of cover material (g/cm^3)	P	Normal
Density of saturated zone (g/m^3)	P	Normal
Depth of roots (m)	P	Uniform
Distribution coefficients (contaminated zone, unsaturated zone, and saturated zone) (cm^3/g)	P	Lognormal
Saturated zone effective porosity	P	Normal
Saturated zone hydraulic conductivity (m/yr)	P	Lognormal
Saturated zone total porosity	P	Normal
Transfer factors for plants	P	Lognormal
Unsaturated zone thickness (m)	P	Lognormal
Aquatic food contaminated fraction	B, P	Triangular
Bioaccumulation factors for fish [(pCi/kg)/(pCi/L)]	P	Lognormal
C-14 evasion layer thickness in soil (m)	P	Triangular
Contaminated zone b parameter	P	Lognormal
Contaminated zone erosion rate (m/yr)	P, B	Empirical (continuous logarithmic)
Contaminated zone hydraulic conductivity (m/yr)	P	Lognormal
Contaminated zone total porosity	P	Normal
Cover erosion rate (m/yr)	P, B	Empirical (continuous logarithmic)
Depth of soil mixing layer (m)	P	Triangular
Drinking water intake (L/yr)	M, B	Lognormal
Evapotranspiration coefficient	P	Uniform
External gamma shielding factor	P	Lognormal

[a] P = physical, B = behavioral, and M = metabolic; when more than one type is listed, the first is primary and the next is secondary.

Table 1-1 Parameters for Which Probability Density Functions Were Developed in the Past (cont.)

Parameter	Parameter Type[a]	Assigned Distribution Type
RESRAD-ONSITE /RESRAD-OFFSITE (cont.)		
Fruit, vegetables, and grain consumption (kg/yr)	M, B	Triangular
Indoor dust filtration factor	P, B	Uniform
Mass loading for inhalation (g/m^3)	P, B	Empirical (continuous linear)
Milk consumption (L/yr)	M, B	Triangular
Runoff coefficient	P	Uniform
Saturated zone b parameter	P	Lognormal
Saturated zone hydraulic gradient	P	Lognormal
Soil ingestion rate (g/yr)	M, B	Triangular
Transfer factors for meat [(pCi/kg)/(pCi/d)]	P	Lognormal
Transfer factors for milk [(pCi/L)/(pCi/d)]	P	Lognormal
Unsaturated zone density (g/cm^3)	P	Normal
Unsaturated zone effective porosity	P	Normal
Unsaturated zone hydraulic conductivity (m/yr)	P	Lognormal
Unsaturated zone, soil b parameter	P	Lognormal
Unsaturated zone total porosity	P	Normal
Weathering removal constant (1/yr)	P	Triangular
Well pump intake depth (below water table) (m)	P	Triangular
Wet foliar interception fraction for leafy vegetables	P	Triangular
Wet-weight crop yields for nonleafy vegetables (kg/m^2)	P	Lognormal
Wind speed (m/s)	P	Bounded lognormal-n
Humidity in air (g/m^3)	P	Lognormal
Indoor fraction	B	Empirical (continuous linear)
Inhalation rate (m^3/yr)	M, P	Triangular
RESRAD-BUILD		
Removable fraction	P, B	Uniform
Resuspension rate (1/s)	P, B	Loguniform
Shielding density (g/cm^3)	P	Uniform
Source density, volume source (g/cm^3)	P	Uniform
Air exchange rate for building and room (1/h)	B	Lognormal
Air release fraction	B	Triangular
Deposition velocity (m/s)	P	Loguniform
Humidity (g/m^3)	P, B	Uniform
Indoor fraction	B	Empirical (continuous linear)
Receptor indirect ingestion rate (m^2/h)	B	Loguniform

[a] P = physical, B = behavioral, and M = metabolic; when more than one type is listed, the first is primary and the next is secondary.

Table 1-1 Parameters for Which Probability Density Functions Were Developed in the Past (cont.)

Parameter	Parameter Type[a]	Assigned Distribution Type
RESRAD-BUILD (cont.)		
Receptor inhalation rate (m^3/d)	M, B	Triangular
Room area (m^2)	P	Triangular
Room height (m)	P	Triangular
Shielding thickness (cm)	P, B	Triangular
Source erosion rate, volume source (cm/d)	P, B	Triangular
Source porosity	P	Uniform
Source thickness, volume source (cm)	P	Triangular
Time for source removal or source lifetime (d)	P, B	Triangular
Volumetric water content	P	Uniform
Water fraction available for evaporation	P	Triangular
Wet and dry zone thickness (cm)	P	Uniform
RESRAD-OFFSITE		
Volumetric water content	P	Continuous linear
Dispersivity (m)	P	Continuous linear
Rainfall erosion index	P	Continuous linear
Soil erodibility factor (ton/acre)	P	Continuous linear
Slope length-steepness factor	P	Continuous linear
Cover and management factor	P, B	Continuous linear
Support practice factor	P, B	Continuous linear
Mass loading for inhalation (g/m^3)	P, B	Continuous linear
Mean onsite mass loading (g/m^3)	P, B	Truncated lognormal-n
Deposition velocity (m/s)	P	Loguniform
Duration of growing season (days)	P	Triangular
Quantity of water for household purposes (L/day)	B, M	Continuous linear
Outdoor time fraction	B	Continuous linear

[a] P = physical, B = behavioral, and M = metabolic; when more than one type is listed, the first is primary and the next is secondary.

In 2002, a data template file was developed for the RESRAD-BUILD code (Biwer et al. 2002) to simulate the Light Industrial use of a decontaminated building as one of the Building Occupancy scenarios as described in NUREG/CR-5512 (Kennedy and Strenge 1992) and NUREG-1757 (NRC 2006) with parameters consistent with the DandD code (McFadden et al. 2001). Template files are useful to save input data for a particular scenario of interest such as the building occupany scenario. The report by Biwer et al. (2002) lists the updated parameter distributions for six RESRAD-BUILD parameters and discusses the process of selecting the appropriate parameters or distributions for use in the data template file for the Building Occupancy scenario.

The RESRAD-OFFSITE code is an extension of the RESRAD-ONSITE code and can model both onsite and offsite receptors. Some parameters used in the RESRAD-OFFSITE code are the same as in the RESRAD-ONSITE code. In 2007, the team developed parameter distributions for the additional parameters used in the RESRAD-OFFSITE code that were not defined in the RESRAD-ONSITE (Yu et al. 2007), as listed in Table 1-1. Also listed in Table 1-1 are updated distributions for those parameters in which new information was found.

Appendix A of this report provide a series of tables which lists the characteristics of current default parameters for the RESRAD-ONSITE Version 7.2, RESRAD-BUILD Version 3.5 and RESRAD-OFFSITE Version 4.0 codes. These tables include the following parameter-related information: parameter name, default value, code-accepted range of values for each parameter, parameter type, references for more information, and a general description of each parameter.

In 2015, Argonne published a new report titled the Data Collection Handbook to Support Modeling Impacts of Radioactive Material in Soil and Building Structures (Yu et al. 2015). To prepare the handbook, the authors conducted a detailed review of available parameter databases. This handbook includes parameter definitions, typical ranges, variations, and measurement methodology. In the handbook, 56 parameters are identified as the most significant parameters based on a detail review of available parameter databases. These 56 parameters and the associated data are discussed in detail in Section 2 of this report.

Changes made in the RESRAD codes since the release of the probabilistic RESRAD-ONSITE Version 6.0 (formerly called RESRAD 6.0), RESRAD-OFFSITE Version 2, and RESRAD-BUILD Version 3.0 (Yu et al. 2000, 2007) are reviewed and discussed in Section 3 of this report.

Probabilistic analyses are performed to evaluate the effect of new parameter values and distributions for a select few radionuclides using the new information that includes updated dose conversion factors. For this evaluation, the Resident Farmer scenario is used for the RESRAD-ONSITE code; the Building Occupancy scenario is used for the RESRAD-BUILD code; and two scenarios described as the Offsite Resident scenario via Water Transport and Offsite Resident scenario via Air Transport are used for the RESRAD-OFFSITE code (see Section 4).

The data in the handbook are used in updating parameter distributions to the extent practicable. Based on the probabilistic analysis, parameters with significant effect on dose are identified, and data are collected, or distributions are developed. Section 5 provides information on the updated parameter distributions which includes a list of parameters and the assigned parameter distribution. Section 5 also discusses the data collection for newly identified parameters such as the distribution coefficient of suspended sediment in surface water body and the distribution coefficient of bottom sediment in surface water body.

The development of the template files for the RESRAD-ONSITE and RESRAD-BUILD codes to simulate the Resident Farmer and the Building Occupancy scenario described in NUREG/CR 5512 (Kennedy and Strenge 1992) and NUREG-1757 (NRC 2006) is discussed in Section 6.

References are listed in Section 7.

2 DATA COLLECTION HANDBOOK REVIEW

The *Data Collection Handbook* (Yu et al. 2015) provides the latest information on 56 parameters. It includes all 51 parameters from the original data collection handbook (Yu et al. 1993) and the 5 transfer factors from the parameter report (Wang et al. 1993). The handbook includes 27 RESRAD-ONSITE, 7 RESRAD-BUILD, and 7 RESRAD-OFFSITE parameters for which distributions were developed in 2000 and 2007. Some of the other parameters included in the handbook are site-specific (e.g., initial concentration of a principal radionuclide, radiation dose limit, radionuclide concentration in groundwater, elapsed time of waste placement, thickness of contaminated zone, area of contaminated zone).

Table 2-1 lists the parameters for which recent data from the handbook are available and lists whether the parameter distributions are available in the handbook. Table 2-1 also lists the code default values used for these parameters in RESRAD-ONSITE, RESRAD-OFFSITE, and RESRAD-BUILD codes. Note RESRAD-BUILD code uses different conceptual models compared to RESRAD-ONSITE and RESRAD-OFFSITE codes, therefore many parameters are not used in RESRAD-BUILD code.

The purpose of determining the (deterministic) defaults for a given scenario is to move from simple prudently conservative calculations towards more realistic simulations. In general, for a parameter that has a significant effect on total dose a realistically conservative value and for other parameters the central values should be used in deterministic analysis for a given scenario if site-specific value is not available. The mean, median, or most likely value depending on the type of probabilistic distribution provides central value for a parameter. For example, for a normal distribution mean value, for a lognormal distribution median value, and for a triangular distribution most likely value can be used as a central value. The current code default values are compared with the central values from the parameter distributions in Table 2-1. This comparison will help in deciding what parameter values can be used in deterministic analysis for a given scenario if site-specific values are not available.

Based on the review of the new information in the handbook Table 2-1 lists 23 parameters for which the parameter values or distributions are very different from the current default values in the code.

Based on this review the parameter distributions are updated in Section 5 for distribution coefficient; root depth, average building air exchange rate; plant, meat, and milk transfer factors; aquatic food bioaccumulation factors; fraction of time spent indoors; and fraction of time spent outdoors.

The values in the handbook for some behavioral parameters such as drinking water intake rate and seafood, leafy vegetable and meat and poultry consumption rates, and livestock water intake rates are different from the default values in the RESRAD codes. The values from the handbook are listed in Table 2-2 and should be considered in selecting input parameter values. Table 2-2 also lists parameters for which distributions are updated based on this review and listed in Appendix C.

Table 2-1 Data Collection Handbook Parameter Review

<table>
<tr><th rowspan="2">Parameter</th><th rowspan="2">Type</th><th rowspan="2">Handbook Section</th><th rowspan="2">Distribution in Handbook</th><th colspan="3">Default</th><th rowspan="2">Revision Needed</th></tr>
<tr><th>RESRAD-ONSITE</th><th>RESRAD-OFFSITE</th><th>RESRAD-BUILD</th></tr>
<tr><td>Soil density (g/cm^3)</td><td>P</td><td>2.1</td><td>No</td><td>Building foundation, 2.4; others, 1.5</td><td>Building foundation, 2.4; others, 1.5</td><td>2.4</td><td>No</td></tr>
<tr><td colspan="8"><u>Notes/Comments</u>:
The handbook suggests using the site-specific values for density. If a site-specific value is not available, use knowledge of soil type to obtain a slightly more accurate estimate of density. If site-specific value or soil type is not known, use default value. The handbook suggests using distributions developed for density of soil of different soil types in NUREG/CR 6697 in probabilistic analysis. For building foundation or source density in RESRAD-BUILD code, shielding density distribution developed in NUREG/CR-6697 for concrete can be used.</td></tr>
<tr><td>Total porosity</td><td>P</td><td>2.2</td><td>No</td><td>Building foundation, 0.1; others 0.4</td><td>Building foundation. 0.1; others, 0.4</td><td>0.1</td><td>No</td></tr>
<tr><td colspan="8"><u>Notes/Comments</u>:
The handbook suggests using the site-specific values for porosity; if a site-specific value is not available, use knowledge of soil type to obtain a slightly more accurate estimate of porosity; if neither site-specific value nor soil type is known, then use default value. The handbook lists range and average values for porosity for various soil types and suggests using the distributions developed for porosity of soil of different soil types in NUREG/CR 6697 in probabilistic analysis.</td></tr>
<tr><td>Effective porosity</td><td>P</td><td>2.3</td><td>No</td><td>0.2</td><td>Contaminated zone, 0.4; unsaturated and saturated zone, 0.2</td><td>Not used</td><td>No</td></tr>
<tr><td colspan="8"><u>Notes/Comments</u>:
The handbook suggests using the site-specific values for effective porosity; if a site-specific value is not available, use knowledge of soil type to obtain a slightly more accurate estimate of effective porosity; if neither site-specific value nor soil type is known, then use default value. Handbook lists range and average values for effective porosity for various soil types and suggests using the distributions developed for effective porosity of soil of different soil types in NUREG/CR 6697 in probabilistic analysis.</td></tr>
<tr><td>Hydraulic conductivity (m/yr)</td><td>P</td><td>2.4</td><td>No</td><td>Contaminated and unsaturated, 10; saturated zone, 100</td><td>Contaminated and unsaturated, 10; saturated zone, 100</td><td>Not used</td><td>No</td></tr>
<tr><td colspan="8"><u>Notes/Comments</u>:
The handbook lists representative values and ranges of hydraulic conductivity for various soil types. It is suggested knowledge of soil type and the direction of flow be used to obtain a slightly more accurate estimate of the parameter. The values in the handbook for different soil types are not very different from the values in NUREG/CR-6697 used in developing parameter distribution.</td></tr>
</table>

Table 2-1 Data Collection Handbook Parameter Review (cont.)

Parameter	Type	Handbook Section	Distribution in Handbook	Default			Revision Needed
				RESRAD-ONSITE	RESRAD-OFFSITE	RESRAD-BUILD	
Soil-specific exponential b parameter	P	2.5	No	5.3	5.3	Not used	No
Notes/Comments: The handbook lists representative values of soil-specific exponential b parameter for various soil types. It is suggested knowledge of soil type be used to obtain a slightly more accurate estimate of the parameter. For most soil types, the values in the handbook are not very different from the values in NUREG/CR-6697 used in developing parameter distribution.							
Erosion rate (m/yr)	P, B	2.6	No	0.001	NA	2.4E-08 cm/d	No
Notes/Comments: The handbook suggests determining the site-specific value for erosion rate. The values listed in the handbook for erosion rate are not different from the values in NUREG/CR-6697 used in developing parameter distribution.							
Hydraulic gradient	P	2.7	No	0.02	0.02	Not used	Yes
Notes/Comments: The handbook suggests determining the site-specific value for hydraulic gradient. According to the handbook, median of the national distribution of hydraulic gradient is 0.006 based on the technical survey of 400 sites across the United States (Newell et al. 1990). The values listed in the handbook are not different from the values in NUREG/CR-6697 used in developing parameter distribution. The deterministic default in the code is different from the median value from the distribution and this difference should be considered and site-specific value should be used in the deterministic analysis.							
Length of contaminated zone parallel to aquifer (m)	P	2.8	No	100	100	Not used	No
Notes/Comments: This parameter is site-specific. The handbook includes how to determine the parameter value.							
Watershed area for nearby stream or pond (m^2)	P	2.9	No	1,000,000	9,000,000	Not used	No
Notes/Comments: This parameter is site-specific. The handbook includes how to determine the parameter value.							

Table 2-1 Data Collection Handbook Parameter Review (cont.)

<table>
<tr><th rowspan="2">Parameter</th><th rowspan="2">Type</th><th rowspan="2">Handbook Section</th><th rowspan="2">Distribution in Handbook</th><th colspan="3">Default</th><th rowspan="2">Revision Needed</th></tr>
<tr><th>RESRAD-ONSITE</th><th>RESRAD-OFFSITE</th><th>RESRAD-BUILD</th></tr>
<tr><td>Water table drop rate (m/yr)</td><td>P</td><td>2.10</td><td>No</td><td>0.001</td><td>Not used</td><td>Not used</td><td>No</td></tr>
<tr><td colspan="8"><u>Notes/Comments</u>:
This parameter is site-specific. The handbook includes how to determine the parameter value.</td></tr>
<tr><td>Well pump intake depth (m)</td><td>P</td><td>2.11</td><td>No</td><td>10</td><td>10</td><td>Not used</td><td>Yes</td></tr>
<tr><td colspan="8"><u>Notes/Comments</u>:
The handbook suggests determining the site-specific value for well pump intake depth. According to the handbook, based on the technical survey of 400 sites across the United States, the median of the national distribution of the saturated thickness of aquifer is 9.09 m. The values listed in the handbook are not different from the values in NUREG/CR-6697 used in developing parameter distribution. The default in the code for well pump intake rate is different from the median value from the distribution and the user should use site-specific value in the deterministic analysis.</td></tr>
<tr><td>Thickness of unsaturated zone (m)</td><td>P</td><td>2.12</td><td>No</td><td>4</td><td>4</td><td>Not used</td><td>No</td></tr>
<tr><td colspan="8"><u>Notes/Comments</u>:
The handbook suggests determining the site-specific value for thickness of unsaturated zone. According to the handbook, based on the technical survey of 400 sites across the United States, the median of the national distribution of the depth to top of aquifer is 4.55 m. The deterministic default in the code for thickness of unsaturated zone is different from the median value from the distribution and the user should use site-specific value in the deterministic analysis.</td></tr>
<tr><td>Distribution coefficients</td><td>P</td><td>2.13</td><td>Yes</td><td>Element-specific</td><td>Element-specific</td><td>Not used</td><td>Yes</td></tr>
<tr><td colspan="8"><u>Notes/Comments</u>:
The handbook has K_d distribution data for different soil types. It lists correlations between K_d and soil properties. The handbook has parameter distribution values for many more elementscompared to the parameter distributions in NUREG-6697 (Yu et al. 2000).</td></tr>
<tr><td>Leach rate</td><td>P</td><td>2.14</td><td>No</td><td>0</td><td>0</td><td>Not used</td><td>No</td></tr>
<tr><td colspan="8"><u>Notes/Comments</u>:
If the value entered is zero the first-order ion-exchange leaching model used in RESRAD-ONSITE estimates the leach rate from the distribution coefficient and other site-specific parameters.</td></tr>
<tr><td>Volumetric water content</td><td>P</td><td>2.15</td><td>No</td><td>Cover material, 0.05; building foundation, 0.03</td><td>Cover material, 0.05; building foundation, 0.03; others, 0.3</td><td>0.03</td><td>No</td></tr>
<tr><td colspan="8"><u>Notes/Comments</u>:
The handbook suggests determining the site-specific value for volumetric water content and provides measurement methodology. No need to change NUREG/CR-6937 distribution used in RESRAD-OFFSITE.</td></tr>
</table>

Table 2-1 Data Collection Handbook Parameter Review (cont.)

Parameter	Type	Handbook Section	Distribution in Handbook	Default			Revision Needed
				RESRAD-ONSITE	RESRAD-OFFSITE	RESRAD-BUILD	
Field capacity	P	2.16	No	0.2	0.3	Not used	No
Notes/Comments: The handbook suggests using the site-specific values for field capacity; if a site-specific value is not available, use knowledge of soil type to obtain a slightly more accurate estimate of field capacity. The handbook provides measurement methodology and lists field capacity for different soil types.							
Precipitation rate (m/yr)	P	3.1	No	1	1	Not used	No
Notes/Comments: The handbook suggests using the site-specific values for precipitation rate and provides measurement methodology. If data on the precipitation rate are not being collected at a site or its vicinity, a site-specific estimation of precipitation rate can be obtained from the U.S. National Weather Service or the U.S. Geological Survey network database.							
Runoff coefficient	P	3.2	No	0.2	0.2	Not used	No
Notes/Comments: The handbook suggests using the site-specific values for runoff coefficient and provides values for different type of areas. The handbook suggests site-specific value based on soil type and land utilization. No need to change parameter distribution in NUREG/CR-6697.							
Evapotrans-piration coefficient	P	3.3	No	0.5	0.5	Not used	No
Notes/Comments: The handbook suggests using the site-specific values for evapotranspiration coefficient and provides measurement methodology. The handbook suggests using National Oceanic and Atmospheric Administration (NOAA) publications to estimate the value of evapotranspiration rate (and ultimately of evapotranspiration coefficient) at any particular location in the United States. No need to change parameter distribution in NUREG/CR-6937.							
Irrigation rate (m/yr)	P	3.4	No	0.2	0.2	Not used	No
Notes/Comments: Default in RESRAD-ONSITE and RESRAD-OFFSITE codes represents the conditions of a relatively humid region. For an arid region, the appropriate generic value is 1 m/yr.							
Average annual wind speed (m/s)	P	3.5	No	2	2	Not used	No
Notes/Comments: The handbook suggests using the site-specific values for average annual wind speed. No need to change parameter distribution in NUREG/CR-6697.							

Table 2-1 Data Collection Handbook Parameter Review (cont.)

Parameter	Type	Handbook Section	Distribution in Handbook	Default			Revision Needed
				RESRAD-ONSITE	RESRAD-OFFSITE	RESRAD-BUILD	
Mass loading for inhalation (g/m^3)	B, P	3.6	No	1.00E-04	1.00E-04	Not used	Yes
Notes/Comments: The handbook provides range of average and 98th percentile $PM_{2.5}$ particulate 24-hr weighted air concentrations. It also provides mass loading depending on human activities such as construction, agriculture, driving on unpaved road, and so on. No need to change parameter distribution in NUREG/CR-6937. The mean or median value from the distribution are very different from the code default values. The site-specific value should be used in the analysis.							
Effective radon diffusion coefficient (m^2/s)	P	4.1	No	Building foundation, 3.0E-07; others, 2.0E-06	Building foundation, 3.0E-07; others, 2.0E-06	2.0E-5	No
Notes/Comments: This parameter is required for radon pathway. The handbook suggests using the site-specific values for effective radon diffusion coefficient and provides measurement methodology. The handbook lists the effective diffusion coefficient values for unconsolidated soil materials, concrete, and other building materials.							
Radon emanation coefficient	P	4.2	No	Rn-222, 0.25 Rn-220, 0.15	Rn-222, 0.25 Rn-220, 0.15	0.2	No
Notes/Comments: This parameter is required for radon pathway. The handbook suggests using the site-specific values for radon emanation coefficient and provides measurement methodology. The handbook lists the Rn-220 and Rn-222 emanation coefficient values for various source materials.							
Radon vertical dimension of mixing (m)	P	4.3	No	2	2	Not used	No
Notes/Comments: It is the height of the rectangular prism within which the gaseous releases are assumed to be mixed to compute onsite exposure from the gaseous releases. It is used in radon pathway dose calculations and for the tritium vapor and C-14 (g) dose calculations.							
Average building air exchange rate (1/h)	B	5.1	Yes	0.5	0.5	0.8	Yes
Notes/Comments: This parameter is required for radon pathway in RESRAD-ONSITE, RESRAD-OFFSITE, and RESRAD-BUILD codes. The handbook suggests using the site-specific values for building air exchange and provides measurement methodology. The handbook lists summary statistics on air exchange rate for residential and nonresidential buildings in different regions of United States. Based on the new information in the handbook, distribution used may be changed.							

Table 2-1 Data Collection Handbook Parameter Review (cont.)

<table>
<tr><th rowspan="2">Parameter</th><th rowspan="2">Type</th><th rowspan="2">Handbook Section</th><th rowspan="2">Distribution in Handbook</th><th colspan="3">Default</th><th rowspan="2">Revision Needed</th></tr>
<tr><th>RESRAD-ONSITE</th><th>RESRAD-OFFSITE</th><th>RESRAD-BUILD</th></tr>
<tr><td>Building room height (m)</td><td>P</td><td>5.2</td><td>No</td><td>2.5</td><td>2.5</td><td>2.5</td><td>No</td></tr>
<tr><td colspan="8"><u>Notes/Comments</u>:
This parameter is required for radon pathway in RESRAD-ONSITE and RESRAD-OFFSITE codes and for air pathway model in RESRAD-BUILD code. The handbook suggests using the site-specific values for building room height. No need to change NUREG/CR-6697 distribution used for RESRAD-BUILD.</td></tr>
<tr><td>Building indoor area factor</td><td>P</td><td>5.3</td><td>No</td><td>0</td><td>0</td><td>Not used</td><td>No</td></tr>
<tr><td colspan="8"><u>Notes/Comments</u>:
This parameter is required for radon pathway in RESRAD-ONSITE and RESRAD-OFFSITE codes.</td></tr>
<tr><td>Building foundation thickness</td><td>P</td><td>5.4</td><td>No</td><td>0.15</td><td>0.15</td><td>Not used</td><td>No</td></tr>
<tr><td colspan="8"><u>Notes/Comments</u>:
This parameter is required for radon pathway in RESRAD-ONSITE and RESRAD-OFFSITE codes.</td></tr>
<tr><td>Foundation depth below ground surface (m)</td><td>P</td><td>5.5</td><td>No</td><td>–1</td><td>–1</td><td>Not used</td><td>No</td></tr>
<tr><td colspan="8"><u>Notes/Comments</u>:
This parameter is required for radon pathway in RESRAD-ONSITE and RESRAD-OFFSITE codes. The foundation depth below ground surface is defined as the vertical distance in the soil immediately from the bottom of the basement floor slab to the ground surface. Due to erosion of the cover and contaminated zones, the thickness of the contaminated zone is time dependent and the foundation depth could be time dependent and less than the (absolute) specified value. A default value of -1 m is used in the codes to adjust the absolute value (if needed) so that the foundation depth will not extend into the contaminated zone.</td></tr>
<tr><td>Filtration factor for inhalation pathway</td><td>P, B</td><td>5.6</td><td>No</td><td>0.4</td><td>0.4</td><td>Not used</td><td>Yes</td></tr>
<tr><td colspan="8"><u>Notes/Comments</u>:
The handbook provides range of average indoor/outdoor filtration factor for four different types of buildings. The filtration factor varies from 0.45 to 0.6. The average values in the handbook are comparable to the values in NUREG/CR-6697 used in developing parameter distribution. No need to change NUREG/CR-6697 distribution used for RESRAD-ONSITE and RESRAD-OFFSITE codes.</td></tr>
</table>

Table 2-1 Data Collection Handbook Parameter Review (cont.)

<table>
<tr><th rowspan="2">Parameter</th><th rowspan="2">Type</th><th rowspan="2">Handbook Section</th><th rowspan="2">Distribution in Handbook</th><th colspan="3">Default</th><th rowspan="2">Revision Needed</th></tr>
<tr><th>RESRAD-ONSITE</th><th>RESRAD-OFFSITE</th><th>RESRAD-BUILD</th></tr>
<tr><td>Shielding factor for external gamma radiation</td><td>P</td><td>5.7</td><td>No</td><td>0.7</td><td>0.7</td><td>Not used</td><td>No</td></tr>
<tr><td colspan="8"><u>Notes/Comments</u>:
The handbook provides average external shielding factors for different types of house construction. There is practically no difference in the values in the handbook compared to the values in NUREG/CR-6697 used in developing the parameter distribution. No need to change NUREG/CR-6697 distribution used for RESRAD-ONSITE and RESRAD-OFFSITE codes.</td></tr>
<tr><td>Root depth (m)</td><td>P</td><td>6.1</td><td>Yes</td><td>0.9</td><td>Fruit, grain, and nonleafy, 1.2; pasture, silage, and leafy, 0.9</td><td>Not used</td><td>Yes</td></tr>
<tr><td colspan="8"><u>Notes/Comments</u>:
Change NUREG/CR-6697 distribution used for RESRAD to match with NUREG/CR-6937 distribution used in RESRAD-OFFSITE.</td></tr>
<tr><td>Livestock water intake rate for beef cattle and milk cows</td><td>M, B</td><td>6.2</td><td>No</td><td>Beef cattle, 50 L/d; milk cows, 160 L/d</td><td>Beef cattle, 50 L/d; milk cows, 160 L/d</td><td>Not used</td><td>Yes</td></tr>
<tr><td colspan="8"><u>Notes/Comments</u>:
The handbook suggests water consumption range 27–55 L/d with average 41 L/d for beef cattle and range 68–155 L/d with average 115 L/d for milk cows. The code defaults are different from the livestock water intake rate in the handbook. The livestock water intake is a behavioral parameter, scenario specific mean value should be used for a deterministic analysis.</td></tr>
<tr><td>Plant transfer factor</td><td>P</td><td>6.3</td><td>Yes</td><td>Element-specific</td><td>Element-specific</td><td>Not used</td><td>Yes</td></tr>
<tr><td colspan="8"><u>Notes/Comments</u>:
The handbook has updated parameter distribution values for many more elements for plant transfer factors and has transfer factors for different plant types.</td></tr>
<tr><td>Meat transfer factors</td><td>P</td><td>6.4</td><td>Yes</td><td>Element-specific</td><td>Element-specific</td><td>Not used</td><td>Yes</td></tr>
<tr><td colspan="8"><u>Notes/Comments</u>:
The handbook has updated parameter distribution values for many more elements for meat transfer factors and has meat transfer factors for goat meat, mutton, pork, poultry, and eggs.</td></tr>
</table>

Table 2-1 Data Collection Handbook Parameter Review (cont.)

<table>
<tr><th rowspan="2">Parameter</th><th rowspan="2">Type</th><th rowspan="2">Handbook Section</th><th rowspan="2">Distribution in Handbook</th><th colspan="3">Default</th><th rowspan="2">Revision Needed</th></tr>
<tr><th>RESRAD-ONSITE</th><th>RESRAD-OFFSITE</th><th>RESRAD-BUILD</th></tr>
<tr><td>Milk transfer factors</td><td>P</td><td>6.5</td><td>Yes</td><td>Element-specific</td><td>Element-specific</td><td>Not used</td><td>Yes</td></tr>
<tr><td colspan="8"><u>Notes/Comments</u>:
The handbook has updated parameter distribution values for many more elements for milk transfer factors and has milk transfer factors for goat milk and sheep milk.</td></tr>
<tr><td>Bio-accumulation factors for aquatic organisms</td><td>P</td><td>6.6</td><td>Yes</td><td>Element-specific</td><td>Element-specific</td><td>Not used</td><td>Yes</td></tr>
<tr><td colspan="8"><u>Notes/Comments</u>:
The handbook has updated parameter distribution values for many more elements for fish bioaccumulation factors and parameter distributions for crustacean, mollusk, and invertebrates bioaccumulation factors.</td></tr>
<tr><td>Drinking water intake rate (L/yr)</td><td>B</td><td>7.1</td><td>No</td><td>510</td><td>510</td><td>Not used</td><td>Yes</td></tr>
<tr><td colspan="8"><u>Notes/Comments</u>:
The handbook lists U.S. Environmental Agency (EPA) recommended mean, 50^{th}, 90^{th}, and 95^{th} per-capita drinking water intake rate for different age groups. The code's default value (510 L/yr) is very different from the EPA recommended mean value (1 L/d) for adults. The value is also different from the mean value in the probabilistic distribution (NUREG/CR-6697).The scenario specific value should be used in the deterministic analysis.</td></tr>
<tr><td>Inhalation rate (m^3/yr)</td><td>B, M</td><td>7.2</td><td>No</td><td>8400</td><td>8400</td><td>18 m^3/d</td><td>No</td></tr>
<tr><td colspan="8"><u>Notes/Comments</u>:
The handbook lists mean and 95^{th} percentile values for long-term exposure for different age groups from different studies. It also has values for short-term exposure in different physical activities to calculate scenario-specific inhalation rate by knowing the activity profile. The RESRAD default value is not much different compared to the inhalation rate for sedentary male workers (ICRP 2002) and matches with the most likely value in the probabilistic distribution (NUREG/CR-6697).</td></tr>
<tr><td>Soil and dust ingestion rate (g/yr)</td><td>M, B</td><td>7.3</td><td>No</td><td>36.5</td><td>36.5</td><td>0</td><td>Yes</td></tr>
<tr><td colspan="8"><u>Notes/Comments</u>:
According to the handbook, recommended EPA mean values for daily intake of soil and dust is 100 and 50 mg/day for 1- to <21-yr-olds and adults in the workplace, respectively. The value is also different from the most likely value in the probabilistic distribution in NUREG/CR-6697. The scenario specific value should be used in the deterministic analysis.</td></tr>
</table>

Table 2-1 Data Collection Handbook Parameter Review (cont.)

Parameter	Type	Handbook Section	Distribution in Handbook	Default			Revision Needed
				RESRAD-ONSITE	RESRAD-OFFSITE	RESRAD-BUILD	
Seafood consumption rate (kg/yr)	M, B	7.4	No	Fish, 5.4; other seafood, 0.9	Fish, 5.4; other seafood, 0.9	Not used	Yes
Notes/Comments: According to the handbook, the recent National Health and Nutrition Examination Survey data compiled by EPA (2011) suggest yearly average total fish consumption rate of ~7.3 kg/yr for adults. The scenario specific value should be used in the deterministic analysis.							
Fruit, vegetable, and grain consumption rate (kg/yr)	M, B	7.5	No	160	160	Not used	Yes
Notes/Comments: According to the handbook, recent National Health and Nutrition Examination Survey data compiled by EPA (2011) suggest yearly average total fruit, vegetable, and grain consumption rate of ~165 kg/yr for adults. The code default is different from the value in the handbook. The handbook suggests using distributions developed in NUREG/CR-6697. The scenario specific value should be used in the deterministic analysis.							
Leafy vegetable consumption rate (kg/yr)	M, B	7.6	No	14	14	Not used	Yes
Notes/Comments: According to the handbook, recent National Health and Nutrition Examination Survey data compiled by EPA (2011) suggest yearly average leafy vegetable consumption rate of about 16.5 kg/yr for adults. Based on the latest information, the code default is different from the average leafy vegetable consumption rate in the handbook. The scenario specific value should be used in the deterministic analysis.							
Meat consumption rate (kg/yr)	M, B	7.7	No	63	63	Not used	Yes
Notes/Comments: According to the handbook, recent studies have reported somewhat higher total meat intake rates ranging from 71 to 76.7 kg/yr. Based on the latest information, the code default is different from the meat intake rate in the handbook. The scenario specific value should be used in the deterministic analysis.							
Milk consumption rate (L/yr)	M, B	7.8	No	92	92	Not used	Yes
Notes/Comments: The handbook includes average intake rates for dairy products and milk. The average value of 103 L/yr for milk consumption is not very different from the most likely value of 102 L/yr for milk consumption rate in NUREG/CR-6697. No need to change NUREG/CR-6697 distribution. Based on the latest information, the code default is different from the average milk consumption rate in the handbook. The scenario specific value should be used in the deterministic analysis.							

Table 2-1 Data Collection Handbook Parameter Review (cont.)

Parameter	Type	Handbook Section	Distribution in Handbook	Default			Revision Needed
				RESRAD-ONSITE	RESRAD-OFFSITE	RESRAD-BUILD	
Area of contaminated zone (m^2)	M, B	8.1	No	10,000	10,000	36	No
Notes/Comments: Site-specific.							
Thickness of contaminated zone (m)	P	8.2	No	2	2	0.15	No
Notes/Comments: This parameter is site-specific. The handbook includes how to determine the parameter value							
Cover depth (m)	P	8.3	No	0	0	0	No
Notes/Comments: This parameter is site-specific. Handbook includes how to determine the parameter value.							
Shape factor	P	8.4	No	Circular	Rectangular	Not used	No
Notes/Comments: This parameter is site-specific. Handbook includes how to determine the parameter value.							
Radiation dose limit (mrem/yr)	P	9.1	No	0.25	0.25	Not used	No
Notes/Comments: Site-specific. The value depends on the regulating agency and assessment context.							
Radionuclide concentration in groundwater (pCi/L)	P	9.2	No	0	Not used	Not used	No
Notes/Comments: Site-specific. The radionuclide concentration in groundwater is only input if elapsed time of waste placement is greater than 0. When these values are greater than 0, method described in Appendix H of RESRAD manual (Yu et al. 2001) is used to calculate distribution coefficient.							

Table 2-1 Data Collection Handbook Parameter Review (cont.)

Parameter	Type	Handbook Section	Distribution in Handbook	Default			Revision Needed
				RESRAD-ONSITE	RESRAD-OFFSITE	RESRAD-BUILD	
Elapsed time of waste placement (yr)	P	9.3	No	0	Not used	Not used	No
Notes/Comments: Site-specific.							
Initial concentration of principal radionuclides (pCi/g)	P	9.4	No	0	0	1	No
Notes/Comments: Site-specific. The user need to input soil concentration for atleast one radionuclide.							
Fraction of time spent indoors	B	9.5	Yes	0.5	0.5	0.5	Yes
Notes/Comments: The handbook includes average time spent indoors at a residence (0.66) and workplace for adult (18–64 yr) (0.23), population/workers in the whole United States and in different census regions. The scenario specific value should be used.							
Fraction of time spent outdoors	B	9.6	Yes	0.25	0.1	Not used	Yes
Notes/Comments: The handbook includes average time spent in outdoor recreational activities (0.15), outdoor at residences (0.1), and outdoor at workplaces (0.23). The scenario specific value should be used.							

Table 2-2 Summary of Parameter Review from Data Collection Handbook

Parameter	Defaults in Codes	Mean or Median Value from Handbook or Distribution	Distribution Updated	Notes/Comments
Hydraulic gradient	0.02	0.006	No	Median of the national distribution of hydraulic gradient is 0.006 based on technical survey of 400 sites across the United States (Newell et al. 1990).
Well pump intake depth (m)	10	9.09	NA	Based on technical survey of 400 sites across the United States, the median of the national distribution of the saturated thickness of aquifer is 9.09 m.
Thickness of unsaturated zone (m)	4	4.55	No	Based on technical survey of 400 sites across the United States, the median of the national distribution for the thickness of unsaturated zone is 4.55 m.
Distribution coefficient (K_d)	Element-specific	Element-specific	Yes	Distributions as well as defaults need to be changed. The codes have more radionuclides and new information available.
Mass loading for inhalation (g/m^3)	1.0E-04	1.0E-06–4.5E-05	No	Handbook provides range of average and 98th percentile $PM_{2.5}$ particulate 24-hr weighted air concentrations.
Average building air exchange rate (1/h)	RESRAD-ONSITE, RESRAD-OFFSITE, 0.5; RESRAD-BUILD, 0.8	Residential, 0.45; nonresidential, 1.5)	Yes	Based on the new information in the handbook, default values as well as distribution used may be changed.
Filtration factor for inhalation pathway	0.4	0.45–0.6	No	The range of average indoor/outdoor filtration factor is based on four different types of buildings.
Root depth (m)	RESRAD-ONSITE, 0.9; fruit, grain, and nonleafy, 1.2; pasture, silage, and leafy 0.9 (RESRAD-OFFSITE)	RESRAD-ONSITE, 0.9; fruit, grain, and nonleafy, 1.2; pasture, silage, and leafy, 0.9 (RESRAD-OFFSITE)	Yes	RESRAD-ONSITE and RESRAD-OFFSITE codes use uniform distribution for root depth. RESRAD-OFFSITE has four plant types with minimum and maximum root depth of 0.3 m and 3.6 m, respectively. Use minimum and maximum values of 0.3 and 3.6 m, respectively, for the root depth in RESRAD-ONSITE, which does not distinguish among the plant types.
Livestock water intake rate for beef cattle (L/d)	50	41	NA	The code defaults are different from the values in the handbook.
Livestock water intake rate for milk cows (L/d)	160	115	NA	The code defaults are different from the values in the handbook.
Plant transfer factor	Element-specific	Element-specific	Yes	Distributions as well as defaults need to be changed. The codes have more radionuclides and new information available.
Meat transfer factors	Element-specific	Element-specific	Yes	Distributions as well as defaults need to be changed. The codes have more radionuclides and new information available.
Milk transfer factors	Element-specific	Element-specific	Yes	Distributions as well as defaults need to be changed. The codes have more radionuclides and new information available.
Bioaccumulation factors for aquatic organisms	Element-specific	Element-specific	Yes	Distributions as well as defaults need to be changed. The codes have more radionuclides and new information available.
Drinking water intake rate (L/yr)	510	365	No	The EPA recommended mean value is 1 L/d for adults.
Soil and dust ingestion rate (g/yr)	36.5	Child, 36.5; adult, 18.25	No	The recommended EPA mean values for daily intake of soil and dust are 100 and 50 mg/day for 1- to <21-yr-old and adult in the workplace, respectively.

Table 2-2 Summary of Parameter Review from Data Collection Handbook (cont.)

Parameter	Defaults in Codes	Mean or Median Value from Handbook or Distribution	Distribution Updated	Notes/Comments
Seafood consumption rate (kg/yr)	Fish, 5.4; other seafood, 0.9)	7.3	NA	The recent National Health and Nutrition Examination Survey data compiled by EPA (2011) suggest yearly average total fish consumption rate of ~7.3 kg/yr for adults.
Fruit, vegetable, and grain consumption rate (kg/yr)	160	165	No	The recent National Health and Nutrition Examination Survey data compiled by EPA (2011) suggest yearly average total fruit, vegetable, and grain consumption rate of ~165 kg/yr for adults.
Leafy vegetable consumption rate, kg/yr	14	16.5	NA	The recent National Health and Nutrition Examination Survey data compiled in EPA (2011) suggest yearly average leafy vegetable consumption rate of about 16.5 kg/yr for adults.
Meat and poultry consumption rate (kg/yr)	63	71–76.7	NA	The recent studies have reported somewhat higher total meat intake rates ranging from 71 to 76.7 kg/yr.
Milk consumption rate (L/yr)	92	103	No	The recent studies have reported average value of 103 L/yr for milk consumption.
Fraction of time spent indoors	0.5	Residence, 0.66; workplace, 0.23	Yes	The recent studies reported time spent indoors at a residence (0.66) and workplace for adults (18–64 yr) (0.23).
Fraction of time spent outdoors	0.25	Recreational activities, 0.15; residence, 0.1; workplace, 0.23	Yes	The recent studies reported time spent in outdoor recreational activities (0.15), at residences (0.1), at workplaces (0.23).

3 CHANGES IN THE RESRAD FAMILY OF CODES

There are no changes to the models used in the current RESRAD-ONSITE (Version 7.2) and RESRAD-BUILD (Version 3.5) codes since 2002. However, many more radionuclides are now available in the database. For the new added radionuclides, radionuclide- and element-specific parameter distributions were not available in the past. The parameters in this category (i.e., for radionuclide- or element-specific parameters) include distribution coefficients, plant transfer factors, meat transfer factors, milk transfer factors, and bioaccumulation factors for aquatic organisms.

For the RESRAD-OFFSITE code, the following changes have been made since the release of Version 2 in June 2007:

- A new module for the primary contamination (1) to provide three new conceptualizations of the primary contamination (model all the solids in the primary contamination layer as being contaminated, model the primary contamination as a homogeneous mixture of contaminated media and clean soil with both solids being equally conductive to infiltration, and model the primary contamination as a mixture of nonconductive radionuclide-bearing material and clean soil through which all the infiltration flows); (2) to simulate three new mechanisms to transfer and release radionuclides to the infiltration out of the primary contamination (equilibrium desorption transfer, equilibrium solubility transfer, and first-order rate-controlled transfer); (3) diffusive transport out of nonconductive radionuclide-bearing material and advective-dispersive transport out of conductive primary contamination; (4) to temporally vary the amount of contaminated media susceptible to transfer radionuclides to the soil moisture, and to temporally vary the properties characterizing the transfer mechanism for solubility and first-order rate-controlled transfer; and (5) to model different transfer mechanisms for parent and progeny radionuclides if necessary (version 4.0).

- An upgraded surface water body module (1) to model water balance including inflow of water from runoff and from the aquifer, and loss by evapotranspiration; (2) to model sediment balance including sediment influx from entire catchment and the isolation of old sediment buried under recent sediment; (3) to model adsorption on suspended sediment; (4) to model adsorption on the surface layer of bed sediment; (5) to provide an option to estimate the sediment delivery ratio using correlation with the area of the entire catchment; (6) to model influx of radionuclides washed off following atmospheric deposition over catchment; and (7) to model contaminated sediment delivery at offsite locations (Version 4.0).

- A revised C-14 model to account for photosynthesis at offsite locations (Version 3.1).

- Resupension of deposited contamination for estimating air concentration at offsite locations (Version 3.2).

- Submerged source/primary contamination (Version 3.2).

- Radon exposure from radon precursor accumulation in offsite soil (Version 3.1).

- Automated area factor calculation for offsite scenarios (Version 3.1).

Table 3-1 shows the improved/added features in the RESRAD-OFFSITE code since Version 2, along with the parameters associated with those changes/improvements. Most of the new parameters added to RESRAD-OFFSITE are site-specific or waste form-specific parameters. The changes to the RESRAD-OFFSITE code, such as the new surface water model (Task 3 of the NRC RESRAD Project) and the new source term model for solubility-limited release and diffusion-controlled release (Task 2 of the NRC RESRAD Project), are also included in Table 3-1.

Table 3-1 Added Features and New Inputs in the RESRAD-OFFSITE Code Since Version 2

New Primary Choice or New Primary Input	New Associated Choices and Inputs	Comment
Source Term Model Updates		
Conceptualization of primary contamination	Select from four options available: • Use RESRAD-ONSITE exponential release model; • Specify initial activity based on mass of entire primary contamination; • Specify initial activity based on mass of contaminated medium; or • Model diffusive transport out of contaminated medium.	Selection depends on waste type and design of waste disposal facility and on the level of modeling detail desired. The choice of the conceptualization applies to all the radionuclides in the input file.
RESRAD-ONSITE exponential release model	Choice of either • Specifying the first-order leach rate, or • Using the specified distribution coefficient to estimate a first-order leach rate.	The release out of the primary contamination is modeled using the leach rate. The release takes the form of a single exponential for parent radionuclides and a series of exponentials for progeny; modified by a linear term to account for erosion. Different choices from the two associated choices can be made for different radionuclides in the same input file.These inputs existed in Version 2.

Table 3-1 Added Features and New Inputs in the RESRAD-OFFSITE Code Since Version 2 (cont.)

New Primary Choice or New Primary Input	New Associated Choices and Inputs	Comment
Source Term Model Updates (cont.)		
Specify initial activity based on mass of entire primary contamination	Choice of either • Modeling multiple forms of contaminated media, or • Modeling a single form of a contaminated medium.	The associated choice applies to all the radionuclides in the input file.
Model multiple forms of contaminated media	First-order transfer rates for each radionuclide in each form. Fraction of inventory of each radionuclide in each form. Time at which the release of each form begins.	The radionuclides in each form will be transferred from the solid phase of the contamination to the water in the contamination beginning at the time specified for that form, at the rate specified for the radionuclide in that form. The time at which the release from a waste form begins applies to all radionuclides in that form. The transfer rates are specific to the waste form and to the radionuclide.
Model a single form of a contaminated medium	Choice of transfer mechanisms: • Equilibrium desorption transfer, • Equilibrium solubility transfer, or • First-order rate-controlled transfer.	The transfer option is specific to the radionuclide, regardless of whether it was initially present or whether it was produced by ingrowth.
Equilibrium desorption transfer	The distribution coefficient of each isotope in the primary contamination (cc/g). Temporal information about the part of the contaminated medium that is prone to release.	Models the transfer from the solid phase of the contaminated medium to the water in the primary contamination by equilibrium desorption followed by advective-dispersive transport within the primary contamination to compute the release out of the primary contamination.

Table 3-1 Added Features and New Inputs in the RESRAD-OFFSITE Code Since Version 2 (cont.)

New Primary Choice or New Primary Input	New Associated Choices and Inputs	Comment
Source Term Model Updates (cont.)		
Equilibrium solubility transfer	Temporal information on the soluble concentration of each element in the primary contamination (g atomic weight/L). Temporal information about the part of the contamination that is prone to release. Maximum number of iterations for solubility release.	Models the transfer from the solid phase of the contaminated medium to the water in the primary contamination by equilibrium dissolution followed by advective-dispersive transport within the primary contamination to compute the release out of the primary contamination.
First-order rate-controlled transfer	Temporal information on the leach rate of each isotope in the primary contamination (1/year). Temporal information about the part of the contamination that is prone to release.	Models the transfer from the solid phase of the contaminated medium to the water in the primary contamination by a first-order rate-controlled process followed by advective-dispersive transport within the primary contamination to compute the release out of the primary contamination.
Model diffusive transport out of contaminated medium	Mass of contaminated medium (kg). Volume of contaminated medium (m^3). Volumetric water content of contaminated medium. The length, width, and height of the representative fragment of contaminated medium for modeling diffusive transport. The diffusion coefficient and the distribution coefficients in the contaminated medium and in the surrounding soil in the primary contamination for each of the radionuclides. Temporal information about the fraction of the contaminated medium that is prone to release.	Transfer from the solid phase of the contaminated medium to the water in the contaminated medium is currently only by equilibrium desorption. Diffusive transport out of the contaminated medium followed by advective-dispersive transport through the surrounding soil in the primary contamination are modeled to compute the release out of the primary contamination.

Table 3-1 Added Features and New Inputs in the RESRAD-OFFSITE Code Since Version 2 (cont.)

New Primary Choice or New Primary Input	New Associated Choices and Inputs	Comment
Source Term Model Updates (cont.)		
Temporal information on release properties	Times at which release begins or changes. The manner in which the release properties change.	
Times at which release begins or changes	The time at which release begins and up to eight times at which the release changes.	The same times apply to all the radionuclides in the input file.
The manner in which the release properties change	Choice of either • Stepwise at the time, or • Linearly over the preceding time interval.	The release properties change in a stepwise fashion at the beginning of the release. Different choices can be made at the other eight times. Different choices can be made for the property that characterizes the release and the releasable fraction. Different choices can also be made for different radionuclides.
Release from the surface layer to the atmosphere or runoff	Choice of either • In the same temporal manner as for release to groundwater, or • Beginning at time zero.	The first choice generally applies.
Area Factors for Small Areas of Elevated Contamination		
Range of X dimension of small area of elevated contamination	Range of Y dimension of small area of elevated contamination (m). Distribution of X and Y dimensions. Number of points on the dose–area plot.	This can range from some fraction of the X dimension of the entire contamination to being equal to the dimension of the entire contamination. These are the bounds of the distribution.
Range of Y dimension of small area of elevated contamination	Choice of either • Being proportional to the X dimension, or • Of a specified range.	
Y dimension proportional to the X dimension	Ratio of Y dimension to X dimension	Ensure that the specified ratio when applied to the range of the X dimension does not cause the Y dimension of the small area to exceed the Y dimension of the entire contamination.

Table 3-1 Added Features and New Inputs in the RESRAD-OFFSITE Code Since Version 2 (cont.)

New Primary Choice or New Primary Input	New Associated Choices and Inputs	Comment
Area Factors for Small Areas of Elevated Contamination (cont.)		
Specify range of Y dimension (m)	Rank correlation coefficient between X and Y dimensions	If a range is specified, this can range from some fraction of the Y dimension of the entire area of contamination to being equal to the dimension of the entire area. The correlation coefficient can be used to ensure that the shape stays within desired proportions.
Distribution of X and Y dimensions	Choice of • Triangle skewed to the high end, • Uniform, or • Triangle skewed to the low end.	Triangle skewed to the high end results in a uniform distribution for the area of the small area of elevated contamination. The other two choices progressively shift the distribution of the area towards the lower end.
Number of points on the dose–area plot	No associated choice or input	Must choose a large number of samples to ensure that the code tabulation of area factor increases with decreasing area.
Location of small area of elevated contamination	Choice of • Small area centered on the entire area, or • Distributed uniformly over the entire area.	Distributing the small area over the entire area produces area factors that can be applied regardless of where the small area of elevated contamination is discovered.
Resuspension of Soil from Offsite Locations		
Mass loading of all particulates at offsite location (g/m^3)	No associated choice or input	Parameter distribution for mass loading is available. Review available information.
Respirable fraction at offsite locations	No associated choice or input	Review available information.

Table 3-1 Added Features and New Inputs in the RESRAD-OFFSITE Code Since Version 2 (cont.)

New Primary Choice or New Primary Input	New Associated Choices and Inputs	Comment
Submerged Primary Contamination		
Fraction of primary contamination that is submerged	No associated choice or input	Site-specific
Main subzones in submerged primary contamination	No associated choice or input	Scenario-specific
Surface Water Model Update		
Distribution coefficient of suspended sediment in surface water body (cm^3/g)	No associated choice or input	Site-specific. Distribution available for soil.
Potential evaporation (m/yr)	No associated choice or input	Site-specific
Stream outflow (as a fraction of total outflow)	No associated choice or input	Value can be input or estimated using inflow ratio. Site-specific
Settling velocity of sediments (cm/s)	No associated choice or input	Site-specific
Density of bottom sediment (g/cm^3)	No associated choice or input	Site-specific
Thickness of bottom sediment layer in adsorption/desorption equilibrium of radionuclides with water (m)	No associated choice or input	Site-specific
Number of catchment areas	Next eleven inputs for each cathchment	Site-specific; can use up to 10 rectangular regions to approximate the catchment.
Catchment area, smaller X coordinate	No associated choice or input	Site-specific
Catchment area, larger X coordinate	No associated choice or input	Site-specific

Table 3-1 Added Features and New Inputs in the RESRAD-OFFSITE Code Since Version 2 (cont.)

New Primary Choice or New Primary Input	New Associated Choices and Inputs	Comment
Surface Water Model Update (cont.)		
Catchment area, smaller Y coordinate	No associated choice or input	Site-specific
Catchment area, larger X coordinate	No associated choice or input	Site-specific
Catchment area, runoff coefficient	No associated choice or input	Site-specific. Parameter distribution available.
Catchment area, soil erodibility factor (ton/acre)	No associated choice or input	Site-specific. Parameter distribution available.
Catchment area, slope-length-steepness factor	No associated choice or input	Site-specific. Parameter distribution available.
Catchment area, cover and management factor	No associated choice or input	Site-specific. Parameter distribution available.
Catchment area, support practice factor	No associated choice or input	Site-specific. Parameter distribution available.
Catchment area, sediment delivery ratio	Choice of • Estimate using area of single catchment, or • Specify value.	
Fraction of deposited radionuclides reaching surface water body	No associated choice or input	Site-specific
Atmospheric deposition on catchment	Choice of • Model the atmospheric deposition on the catchment, or • Approximate it by the release to the atmosphere.	
Convergence criterion for atmospheric deposition	No associated choice or input	Input required when atmospheric deposition on catchment area is modeled.

Table 3-1 Added Features and New Inputs in the RESRAD-OFFSITE Code Since Version 2 (cont.)

New Primary Choice or New Primary Input	New Associated Choices and Inputs	Comment
Surface Water Model Update (cont.)		
Fraction of eroded radionuclides deposited at dwelling site	No associated choice or input	Site-specific
Fraction of eroded radionuclides deposited in the nonleafy vegetable plot	No associated choice or input	Site-specific
Fraction of eroded radionuclides deposited in the leafy vegetable plot	No associated choice or input	Site-specific
Fraction of eroded radionuclides deposited in the pasture plot	No associated choice or input	Site-specific
Fraction of eroded radionuclides deposited in the feed grain plot	No associated choice or input	Site-specific
Fraction of eroded radionuclides deposited in the surface water body	No associated choice or input	Site-specific

4 PROBABILISTIC ANALYSIS TO IDENTIFY PARAMETERS WITH SIGNIFICANT EFFECT ON DOSE

The Consolidated Decommissioning Guidance, NUREG-1757, (NRC 2006) provides guidance and the technical basis regarding dose modeling for demonstrating compliance with radiological criteria. The NRC prescribed a graded approach to dose modeling, from a conservative screening dose assessment to a site-specific analysis. The DandD code, developed by NRC (McFadden et al. 2001), uses a screening dose assessment approach as described in NUREG/CR 5512 (Kennedy and Strenge 1992) to allow licensees to perform simple estimates of the annual dose from residual radioactivity in soils and building surfaces. For a more flexible dose assessment approach, a site-specific analysis is used to allow licensees to tailor the analysis to their site conditions with proper justification. As stated in NUREG-1757, site-specific analyses would require the licensee to provide justifications and site-specific information, as necessary, to support changes in parameters or changes of codes/models, and default assumptions.

The RESRAD family of codes uses site-specific analyses to demonstrate compliance with the dose criteria in Subpart E of 10 CFR Part 20. For site-specific analyses, assessing the uncertainty in dose assessments should be considered due to the lack of specific information about the site. By performing an uncertainty analysis, important assumptions and parameter values can be identified that influence decisions about the site. Furthermore, a sensitivity analysis provides a tool for understanding and explaining the influence of these key assumptions and parameters values on the variability of the estimated dose

For a site-specific analysis, new parameter values and distributions may have the potential to have significant effect on the dose/risk and these effects should be evaluated. In this section, probabilistic analyses are performed to evaluate the effect of new parameter values and distributions using new information such as updated dose coefficients, transfer factors, distribution coefficients, and bioaccumulation factors for fish and crustacean. For this evaluation, the Resident Farmer scenario is used for the RESRAD-ONSITE code, and the Building Occupancy scenario is used for the RESRAD-BUILD code. The behavioral and metabolic parameters used in the analysis are kept at DandD defaults.

The Resident Farmer scenario analysis is based on the following assumptions:

- Radioactive contamination occurs in a surface soil layer with no cover and there is no existing groundwater contamination.
- The property is used for residential and farming activities.
- Residency can occur immediately after release of the property.
- Radioactive dose results from exposure via the following exposure pathways:
    - Direct exposure to external radiation from the contaminated soil material,
    - Internal dose from inhalation of airborne radionuclides, including radon progeny,
    - Internal dose from ingestion of the following:
        - Plant foods grown in the contaminated soil and irrigated with contaminated water,

    - Meat and milk from livestock fed with contaminated fodder and water,
    - Drinking water from a contaminated well or surface water body,
    - Fish from a contaminated surface water body, and
    - Contaminated soil.

The Building Occupancy scenario analysis is based on the following assumptions:

- The building will be commercially used after decommissioning.
- The occupancy of the building will occur immediately after release.
- The residual contamination will be represented by a surface residual radioactivity left on the inner building surfaces.
- The removable fraction will be 10 percent.
- The exposure type will be a long-term chronic exposure to low-level radioactive contamination because major contamination will have been cleaned up before decommissioning of the building.
- Radioactive dose results from exposure via the following exposure pathways:
    - External exposure to penetrating radiation from surface sources,
    - Inhalation of resuspended surface contamination,
    - Inadvertent ingestion of surface contamination directly from the source,
    - Inadvertent ingestion of materials deposited on the surfaces,
    - External exposure from deposited material,
    - External exposure during submersion in airborne radioactive dust, and
    - Inhalation of indoor radon aerosol.

The parameters with a significant effect on dose in the RESRAD-OFFSITE code are identified by probabilistic calculations using two site-specific scenarios. For both scenarios, the receptor is located offsite at some distance from the primary contamination. The first scenario, termed Offsite Resident scenario via Water Transport, considered mainly exposure from water-dependent pathways. The second scenario, termed Offsite Resident scenario via Air Transport, considered exposure from all exposure pathways.

In the Offsite Resident scenario via Water Transport scenario, the groundwater well and the surface water body are downgradient. The groundwater also discharges to a surface water body. This scenario assumes 50 percent of the water use is from groundwater, and 50 percent is from surface water for drinking and irrigation. This scenario mainly considers water-dependent pathways. The direct external exposure, dust inhalation, and radon inhalation pathways are not active. The radionuclides become releasable linearly over time: 50 percent of the source is initially releasable and 50 percent transforms to a releasable form later. First and second release times (0 and 200 years) have a uniform distribution (0 – 100 years for the first release time and 100 – 300 years for the second release time). Release mechanism is first-order rate-controlled release with transport. Initial leach rate is low, and final leach rate is 10 times higher. The source has a cover that erodes over time. Release from the surface layer is in the same manner as for release to groundwater.

In the Offsite Resident scenario via Air Transport scenario, this scenario considers all exposure pathways including radon inhalation. The source has no cover. Release from the surface layer begins at time zero. Release to groundwater occurs after a delay of 100 years. Release mechanism is equilibrium desorption release. The groundwater well and surface water body are downgradient. The groundwater also discharges to a surface water body. This scenario assumes that 100 percent water use is from surface water. Table 4-1 lists the assumptions and the main parameters used in both scenarios.

Table 4-1 Assumptions Associated with Offsite Resident Scenario via Water Transport and Air Transport Scenarios

Pathways/Parameters/Assumptions	Offsite Resident Scenario 1 Water Transport	Offsite Resident Scenario 2 Air Transport
Pathways suppressed	External, dust inhalation, radon inhalation	None
Conceptualization of primary contamination	Specify initial activity based on mass of entire primary contamination.	Specify initial activity based on mass of entire primary contamination
Default release mechanism	First-order rate-controlled release	Equilibrium desorption release
Time at which release begins or changes for release to groundwater (yr)	Two times selected (0 and 200 yerars) and uniform distribution on the times (0 – 100 for the first time and 100 – 300 for the second time) used.	100 years
Release from surface layer	In the same manner as for release to groundwater	Beginning at time zero
Leach rates	Small leach rate initially (0.001) and changes to large value (0.01) at the second time	Primary contamination area; K_d values are used.

Table 4-1 Assumptions Associated with Offsite Resident scenario via Water Transport and Air Transport Scenarios (cont.)

Pathways/Parameters/Assumptions	Offsite Resident Scenario 1 Water Transport	Offsite Resident Scenario 2 Air Transport
Water use	50 percent from surface water and 50 percent from groundwater	100 percent from surface water
Location of well and surface water body	Located downgradient from primary contamination (uniform distribution well at 50–200 m; surface water body 225–900 m)	Located downgradient from primary contamination (uniform distribution well at 50–200 m; surface water body 225–900 m)
Cover	Triangular distribution 0, 0.15, 0.3 and erodes over time	None
Source thickness	Uniform distribution 1–3 m	Uniform distribution 1–3 m and also includes surface erosion going to surface water
Receptor location	Offsite	Offsite
Infiltration rate	Probabilistic analysis on multiple parameters that are used to calculate infiltration rate	Probabilistic analysis on multiple parameters that are used to calculate infiltration rate
Radionuclides selected	C-14, Co-60, Cs-137, H-3, I-129, Np-237, Pu-239, Ra-226, Ra-228, Sr-90, Tc-99, U-238	C-14, Co-60, Cs-137, H-3, I-129, Np-237, Pu-239, Ra-226, Ra-228, Sr-90, Tc-99, U-238
Time span	Radionuclide-dependent varying from 300 to 10,000 years.	Radionuclide-dependent varying from 300 to 10,000 years.

4.1 Resident Farmer Scenario Analysis

Section B.1 in Appendix B provides the details of the analysis and lists all the parameters used in the Resident Farmer scenario. Tables B-11 through B-22 list the reported results for the Resident Farmer scenario for soil contamination by each of the 12 radionuclides selected for evaluation.

Pathways that contribute significantly to the total dose depend on the radionuclide at the dose percentile selected. Dominant exposure pathways at 50 percent and 95 percent are highlighted in Tables B-11 through B-22. Table B-23 presents the dominant exposure pathways identified for dose percentiles 50 percent and 95 percent by radionuclide and compares them with dominant exposure pathways identified from deterministic analysis. For probabilistic analysis, any pathway with 50^{th} or 95^{th} percentile dose that is more than 5 percent of the 50^{th} or 95^{th} percentile peak total dose was considered significant in this analysis.Table 4-2 lists the peak total dose distribution from probabilistic calculations for all radionuclides analyzed in the Resident Farmer scenario. The peak dose-to-source ratio (mrem/yr per pCi/g) at 95 percent varied from 0.12 (H-3) to 58 (Ra-226). The relative variability in dose distribution captured by the ratio of peak total dose at 95 percent to 50 percent (listed in last row of Table 4-2) was small for Co-60 (1.9) and large for Sr-90 (6.9). For other radionuclides, relative variability was >1.9 and <6.9.

Table 4-2 Distribution of Peak Total Dose Obtained with Probabilistic Calculations in the Resident Farmer Scenario for Different Radionuclides Analyzed (mrem/yr per pCi/g)

Percentile	C-14	Co-60	Cs-137	H-3	I-129	Np-237	Pu-239	Ra-226	Ra-228	Sr-90	Tc-99	U-238
5	1.07E-01	2.55E+00	7.79E-01	3.68E-03	4.34E-01	3.81E-01	2.50E-02	5.43E+00	3.13E+00	3.48E-01	7.94E-02	6.57E-02
10	1.53E-01	2.78E+00	8.58E-01	6.51E-03	6.00E-01	4.48E-01	3.05E-02	6.66E+00	3.80E+00	5.61E-01	1.44E-01	7.65E-02
15	1.93E-01	2.96E+00	9.33E-01	9.99E-03	7.57E-01	5.03E-01	3.64E-02	7.75E+00	4.47E+00	7.74E-01	2.02E-01	8.50E-02
20	2.38E-01	3.12E+00	1.00E+00	1.38E-02	8.93E-01	5.57E-01	4.21E-02	8.76E+00	5.12E+00	9.99E-01	2.74E-01	9.34E-02
25	2.84E-01	3.26E+00	1.06E+00	1.82E-02	1.04E+00	6.13E-01	4.79E-02	9.78E+00	5.78E+00	1.25E+00	3.51E-01	1.02E-01
30	3.26E-01	3.42E+00	1.12E+00	2.27E-02	1.20E+00	6.72E-01	5.44E-02	1.09E+01	6.46E+00	1.51E+00	4.30E-01	1.10E-01
35	3.71E-01	3.57E+00	1.19E+00	2.83E-02	1.35E+00	7.39E-01	6.18E-02	1.20E+01	7.17E+00	1.78E+00	5.21E-01	1.20E-01
40	4.20E-01	3.73E+00	1.25E+00	3.45E-02	1.55E+00	8.09E-01	6.96E-02	1.32E+01	7.94E+00	2.10E+00	6.13E-01	1.30E-01
45	4.68E-01	3.88E+00	1.32E+00	4.07E-02	1.73E+00	8.84E-01	7.77E-02	1.44E+01	8.88E+00	2.45E+00	7.21E-01	1.39E-01
50	5.11E-01	4.04E+00	1.39E+00	4.72E-02	1.95E+00	9.63E-01	8.73E-02	1.57E+01	9.94E+00	2.87E+00	8.41E-01	1.50E-01
55	5.62E-01	4.22E+00	1.46E+00	5.32E-02	2.23E+00	1.07E+00	9.84E-02	1.71E+01	1.12E+01	3.34E+00	9.78E-01	1.62E-01
60	6.16E-01	4.42E+00	1.55E+00	5.95E-02	2.52E+00	1.18E+00	1.10E-01	1.88E+01	1.27E+01	3.92E+00	1.15E+00	1.77E-01
65	6.81E-01	4.63E+00	1.65E+00	6.63E-02	2.89E+00	1.31E+00	1.26E-01	2.09E+01	1.43E+01	4.65E+00	1.33E+00	1.96E-01
70	7.57E-01	4.88E+00	1.76E+00	7.28E-02	3.31E+00	1.49E+00	1.43E-01	2.31E+01	1.63E+01	5.43E+00	1.57E+00	2.16E-01
75	8.36E-01	5.19E+00	1.88E+00	8.02E-02	3.92E+00	1.66E+00	1.65E-01	2.59E+01	1.86E+01	6.54E+00	1.85E+00	2.42E-01
80	9.40E-01	5.52E+00	2.05E+00	8.79E-02	4.69E+00	1.91E+00	1.93E-01	2.95E+01	2.20E+01	8.09E+00	2.29E+00	2.76E-01
85	1.06E+00	5.95E+00	2.28E+00	9.54E-02	5.87E+00	2.25E+00	2.35E-01	3.45E+01	2.63E+01	1.01E+01	2.79E+00	3.26E-01
90	1.21E+00	6.56E+00	2.61E+00	1.07E-01	7.63E+00	2.79E+00	2.95E-01	4.23E+01	3.29E+01	1.35E+01	3.68E+00	4.08E-01
95	1.46E+00	7.49E+00	3.36E+00	1.23E-01	1.16E+01	3.89E+00	4.14E-01	5.82E+01	4.58E+01	1.98E+01	5.28E+00	6.13E-01
Max	4.48E+00	1.10E+01	3.08E+01	2.47E-01	1.60E+02	1.63E+01	4.93E+00	4.84E+02	2.65E+02	3.30E+02	9.10E+01	5.76E+00
Mean	6.13E-01	4.40E+00	1.67E+00	5.28E-02	3.57E+00	1.41E+00	1.39E-01	2.18E+01	1.56E+01	5.70E+00	1.56E+00	2.23E-01
Ratio (95/50)	2.85E+00	1.85E+00	2.41E+00	2.60E+00	5.95E+00	4.04E+00	4.75E+00	3.71E+00	4.61E+00	6.88E+00	6.28E+00	4.09E+00

Table 4-3 lists important exposure pathways identified that contribute to variability in peak dose distribution for the 12 radionuclides selected in the Resident Farmer scenario.

Table 4-3 Important Exposure Pathways Identified for the 12 Radionuclides Selected in the Resident Farmer Scenario

Radionuclides	Water-Independent Pathways						
	External Ground	Inhalation	Radon	Plant Ingestion	Meat Ingestion	Milk Ingestion	Soil Ingestion
C-14				X	X	X	
Co-60	X			X			
Cs-137	X			X	X	X	
H-3				X	X	X	
I-129				X	X	X	
Np-237	X			X			
Pu-239				X			
Ra-226	X		X	X			
Ra-228	X			X		X	
Sr-90				X		X	
Tc-99				X		X	
U-238	X			X		X	

	Water-Dependent Pathways					
	Water Ingestion	Fish Ingestion	Radon	Plant Ingestion	Meat Ingestion	Milk Ingestion
C-14						
Co-60						
Cs-137						
H-3	X					
I-129	X					
Np-237	X					
Pu-239						
Ra-226						
Ra-228						
Sr-90						
Tc-99	X					
U-238						

Note: “X” indicates important exposure pathway contributing in the peak total dose variability. Any pathway that contributed more than 5 percent in the peak total dose absolute variability was considered significant in this analysis.

Table 4-4 lists parameters (a total of 35) associated with each radionuclide with a significant effect on dose for the Resident Farmer scenario. The parameters with a significant effect on dose depend on the dominant exposure pathways and their variability in peak total dose distribution. Table 4-5 lists the effect and significance of parameters in the Resident Farmer scenario analysis.

Table 4-4 Parameters with High Correlation with Dose for the Resident Farmer Scenario

Parameter to Which the Peak Total Dose Is Sensitive	**C-14**	**Co-60**	**Cs-137**	**H-3**	**I-129**	**Np-237**	**Pu-239**	**Ra-226**	**Ra-228**	**Sr-90**	**Tc-99**	**U-238**
Thickness of contaminated zone	+++	+	+++	+++	+++	+++	+++	+++	+++	+++	+++	+++
Area of contaminated zone	+++	+	+									
Density of contaminated zone	++		+	++				+				
External gamma shielding factor		+++	+++			+++		++	++			++
Depth of roots			---	---	---	---	---	---	---	---	---	--
Contaminated zone b parameter				–								
Contaminated zone hydraulic conductivity				+								
Contaminated zone total porosity				–				–				
K_d in contaminated zone				–							+	
Effective porosity of unsaturated zone									+			
Total porosity of unsaturated zone							+					
K_d in unsaturated zone												
Livestock fodder intake for milk			+	+								
Livestock intake of soil			+		+							++
Livestock water intake for milk				–								
Meat transfer factor			++		++		+					
Milk transfer factor			++		+++				+	+	+	+++
Plant transfer factor		+	+++		+++	+++	+++	+++	+++	+++	+++	+++
Plant transfer factor for progeny								++				
Saturated zone effective porosity						–						
Saturated zone hydraulic conductivity					++							
Saturated zone hydraulic gradient					+							
K_d in saturated zone					--	–						

The influence of a parameter is categorized subjectively into three groups: those with standardized rank regression coefficient (SRRC) >0.2 are shown with +++ or ---; those with an SRRC in the range ≥0.1 to 0.2 are shown with ++ or --; and those with an SRRC in the range ≥0.05 to <0.1 are shown with + or -. Symbol “+” is used when an increase in the parameter value increases dose, and symbol “−“is used when an increase in the parameter value decreases dose.

Table 4-4 Parameters with High Correlation with Dose for the Resident Farmer Scenario (cont.)

Parameter to Which the Peak Total Dose Is Sensitive	C-14	Co-60	Cs-137	H-3	I-129	Np-237	Pu-239	Ra-226	Ra-228	Sr-90	Tc-99	U-238
Precipitation				--								
Runoff coefficient				++							+	
Rn-222 emanation coefficient								+++				
Building foundation radon diffusion coefficient								++				
Building foundation thickness								--				
Building foundation total porosity								++				
Building air exchange rate								---				
Building room height								--				
C-14 evasion flux rate from soil	+											
Thickness of evasion layer of C-14 in soil	+											
Wind speed	---											

The influence of a parameter is categorized subjectively into three groups: those with standardized rank regression coefficient (SRRC) >0.2 are shown with +++ or ---; those with an SRRC in the range ≥0.1 to 0.2 are shown with ++ or --; and those with an SRRC in the range ≥0.05 to <0.1 are shown with + or -. Symbol "+" is used when an increase in the parameter value increases dose, and symbol "−"is used when an increase in the parameter value decreases dose.

Table 4-5 Effect of Parameters Contributing Significantly to Pathway Doses for the Resident Farmer Scenario

Parameter	Effect	Significance	Comment
Thickness of contaminated zone Area of contaminated zone	Area factor cover-and-depth factor	All pathways	The thickness and area of contaminated zone determine the extent of contamination and used in calculating area factor and depth-and-cover factor in multiple exposure pathways
Density of contaminated zone	Total activity	External, water-dependent pathways, C-14, H-3, radon	Density of contaminated zone determines the total amount of radionuclides in the source volume.
External gamma shielding factor	External gamma shielding	Direct external exposure	External gamma shielding factor accounts for the attenuation of gamma radiation by building materials.

Table 4-5 Effect of Parameters Contributing Significantly to Pathway Doses for the Resident Farmer Scenario (cont.)

Parameter	Effect	Significance	Comment
Depth of roots	Plant concentration	Plant, meat, and milk	Depth of roots calculates the cover-and-depth factor (Appendix D, Yu et al. 2001) for the plant, meat, and milk exposure pathways.
Contaminated zone b parameter Contaminated zone hydraulic conductivity	Soil and water concentration	All pathways	The hydraulic conductivity in the contaminated zone is used along with the water infiltration rate and soil b parameter to determine the water saturation ratio in soil, which is then used to determine the leach rate of contaminants.
Contaminated zone total porosity			The total porosity along with saturation ratio determines the moisture content of soil, which in turn is used to determine the retardation factor and transport speed of water in the contaminated zone.
K_d in contaminated zone			K_d values estimate the retardation factors. Higher K_d values result in greater soil retention and slower radionuclide movement.
Effective porosity of unsaturated zone	Transport through unsaturated zone	Water-dependent pathways	Effective porosity of unsaturated zone determines the transport through the unsaturated zone and breakthrough time.
Total porosity of unsaturated zone			Total porosity of unsaturated zone determines the transport through the unsaturated zone and breakthrough time.
Livestock fodder intake for milk	Milk concentration	Milk	Livestock fodder intake for milk determines the daily intake of fodder by livestock kept for milk consumption. Higher contaminated fodder intake will result in higher concentration of radionuclides in milk.
Livestock intake of soil	Meat and milk concentration	Meat, milk	Livestock intake of soil determines the daily intake of soil by livestock kept for meat and milk consumption. Higher contaminated soil intake results in higher concentration of radionuclides in meat and milk.
Livestock water intake for milk	Milk concentration	Milk	Livestock water intake for milk determines the daily intake of water by livestock kept for milk consumption. Higher contaminated fodder intake results in higher concentration of radionuclides in milk.
Plant transfer factor	Plant concentration	Plant, meat, milk	Plant transfer factor determines the concentration of radionuclides in plant.
Meat and milk transfer factor	Meat and milk concentration	Meat, milk	Meat and milk transfer factors determine the concentration of radionuclides in meat and milk.
Saturated zone effective porosity Saturated zone hydraulic conductivity Saturated zone hydraulic gradient	Water concentration	Water-dependent pathways	Saturated zone effective porosity determines the rise time (i.e., the time required to transport groundwater from the upgradient edge to downgradient edge of the saturated zone). Saturated zone hydraulic conductivity and hydraulic gradient determine the flow rate. Groundwater flow rate affects the rise time as well as the dilution factor of radionuclides in well water.

Table 4-5 Effect of Parameters Contributing Significantly to Pathway Doses for the Resident Farmer Scenario (cont.)

Parameter	Effect	Significance	Comment
Precipitation and runoff	Infiltration rate	All pathways	Precipitation and runoff coefficient are used in calculating infiltration rate of contaminant from contaminated zone.
Rn-222 emanation coefficient	Radon concentration	Radon	The rate of radon generation in the pore volume depends on the radon emanation coefficient, bulk density of the material, and total porosity. The radon flux depends on the gradient of radon concentration in the pore space, total porosity, and radon diffusion coefficient. The radon concentration indoor depends on the building characteristics and radon flux.
Building foundation radon diffusion coefficient			
Building characteristics (room height and air exchange rate)			
C-14 evasion flux rate from soil	C-14 concentration in different media	C-14	The C-14 evasion flux rate from soil determines the rate at which C-14 is released into the atmosphere.
Thickness of evasion layer of C-14 in soil			Thickness of evasion layer of C-14 in soil affects the evasion of C-14.
Wind speed			C-14 evasion flux from the contaminated area along with wind speed and contaminated zone area, thickness, and density calculate C-14 concentration in air. The C-14 concentration in air is used in calculating C-14 concentration in plant. Higher C-14 concentration in air results in higher plant concentration and higher plant, meat, and milk pathway doses.

4.2 Building Occupancy Scenario Analysis

Appendix B provides the details of the analysis and lists all the parameters used in the Building Occupancy scenario (Table B-26). Table B-27 lists peak total dose and contribution from different exposure pathways in a deterministic analysis. Tables B-28 through B-39 list the reported results for the Building Occupancy scenario concerning building surface contamination by each of the 12 radionuclides selected for evaluation.

Pathways that contribute significantly to the total dose depend on the radionuclide at the dose percentile selected. Dominant exposure pathways at 50 percent and 95 percent are highlighted in Tables B-28 through B-39. Table B-40 presents the dominant exposure pathways identified for 50 percent and 95 percent dose percentiles by radionuclides and compares them with dominant exposure pathways identified from deterministic analysis. The dominant exposure pathways are defined as pathways that contribute more than 5 percent to the total dose.

Table 4-6 lists peak total dose distribution from probabilistic calculations for all radionuclides analyzed in the Building Occupancy scenario. The peak dose-to-source ratio (mrem/yr per pCi/m^2) at 95 percent varied from 2.24E-08 (H-3) to 4.88E-04 (Np-237). The relative variability in dose distribution captured by the ratio of peak dose at 95 percent to 50 percent (listed in last row of Table 5-6) was small for Co-60 (1.0) and large for C-14 (3.19). For other radionuclides, relative variability ranged from >1.0 to <3.19. Table 4-7 lists important exposure pathways identified that contribute to peak total dose variability for the 12 radionuclides selected in the Building Occupancy scenario.

Table 4-8 lists parameters (a total of 8) associated with each radionuclide with a significant effect on dose for the Building Occupancy scenario. The parameters with a significant effect on dose depend on the dominant exposure pathways and their variability in dose distribution. Table 4-9 lists the effect and significance of parameters in the Building Occupancy scenario analysis.

Table 4-6 Distribution of Peak Total Dose Obtained with Probabilistic Calculations in the Building Occupancy Scenario for Different Radionuclides Analyzed (mrem/yr per pCi/m²)

Percentile	C-14	Co-60	Cs-137	H-3	I-129	Np-237	Pu-239	Ra-226	Ra-228	Sr-90	Tc-99	U-238
5	5.40E-08	4.16E-05	1.14E-05	1.62E-08	7.74E-06	1.66E-04	1.29E-04	7.58E-05	1.05E-04	4.09E-06	3.94E-08	1.78E-05
10	5.40E-08	4.16E-05	1.14E-05	1.62E-08	7.75E-06	1.71E-04	1.33E-04	7.73E-05	1.14E-04	4.11E-06	3.95E-08	1.90E-05
15	5.40E-08	4.16E-05	1.14E-05	1.63E-08	7.75E-06	1.76E-04	1.37E-04	7.82E-05	1.22E-04	4.12E-06	3.96E-08	2.00E-05
20	5.40E-08	4.16E-05	1.14E-05	1.63E-08	7.76E-06	1.82E-04	1.42E-04	7.88E-05	1.30E-04	4.13E-06	3.96E-08	2.10E-05
25	5.40E-08	4.16E-05	1.14E-05	1.63E-08	7.76E-06	1.87E-04	1.45E-04	7.92E-05	1.36E-04	4.14E-06	3.97E-08	2.21E-05
30	5.40E-08	4.16E-05	1.14E-05	1.63E-08	7.76E-06	1.92E-04	1.49E-04	7.93E-05	1.42E-04	4.15E-06	3.98E-08	2.30E-05
35	5.40E-08	4.16E-05	1.14E-05	1.64E-08	7.77E-06	1.96E-04	1.53E-04	7.94E-05	1.46E-04	4.16E-06	3.99E-08	2.39E-05
40	5.41E-08	4.16E-05	1.14E-05	1.64E-08	7.77E-06	2.01E-04	1.56E-04	7.96E-05	1.50E-04	4.18E-06	4.00E-08	2.48E-05
45	5.41E-08	4.16E-05	1.14E-05	1.64E-08	7.77E-06	2.06E-04	1.61E-04	7.97E-05	1.52E-04	4.19E-06	4.01E-08	2.58E-05
50	5.41E-08	4.16E-05	1.14E-05	1.65E-08	7.78E-06	2.12E-04	1.65E-04	7.98E-05	1.54E-04	4.20E-06	4.02E-08	2.71E-05
55	5.43E-08	4.16E-05	1.14E-05	1.65E-08	7.80E-06	2.17E-04	1.70E-04	7.99E-05	1.55E-04	4.22E-06	4.04E-08	2.82E-05
60	5.45E-08	4.16E-05	1.14E-05	1.66E-08	7.83E-06	2.24E-04	1.75E-04	8.01E-05	1.56E-04	4.24E-06	4.07E-08	2.94E-05
65	5.51E-08	4.16E-05	1.14E-05	1.67E-08	7.90E-06	2.32E-04	1.81E-04	8.04E-05	1.57E-04	4.26E-06	4.10E-08	3.09E-05
70	5.59E-08	4.16E-05	1.14E-05	1.68E-08	8.01E-06	2.40E-04	1.88E-04	8.08E-05	1.58E-04	4.29E-06	4.15E-08	3.25E-05
75	5.72E-08	4.16E-05	1.15E-05	1.71E-08	8.19E-06	2.54E-04	1.99E-04	8.15E-05	1.59E-04	4.33E-06	4.24E-08	3.45E-05
80	6.07E-08	4.16E-05	1.15E-05	1.75E-08	8.66E-06	2.68E-04	2.10E-04	8.33E-05	1.60E-04	4.39E-06	4.46E-08	3.71E-05
85	6.98E-08	4.17E-05	1.15E-05	1.82E-08	9.90E-06	2.96E-04	2.32E-04	8.83E-05	1.61E-04	4.50E-06	5.13E-08	4.01E-05
90	9.32E-08	4.17E-05	1.17E-05	1.97E-08	1.31E-05	3.49E-04	2.74E-04	1.01E-04	1.62E-04	4.71E-06	6.79E-08	4.49E-05
95	1.73E-07	4.17E-05	1.19E-05	2.24E-08	2.45E-05	4.88E-04	3.80E-04	1.48E-04	1.66E-04	5.19E-06	1.28E-07	5.72E-05
Max	8.07E-08	4.16E-05	1.15E-05	1.73E-08	1.18E-05	2.76E-04	2.15E-04	9.24E-05	1.46E-04	4.34E-06	6.12E-08	3.19E-05
Mean	1.95E-06	4.20E-05	1.31E-05	3.48E-08	3.27E-04	5.37E-03	4.02E-03	8.79E-04	1.98E-04	7.82E-06	1.71E-06	3.46E-04
Ratio (95/50)	3.19E+00	1.00E+00	1.04E+00	1.36E+00	3.15E+00	2.31E+00	2.30E+00	1.85E+00	1.08E+00	1.23E+00	3.17E+00	2.11E+00

Table 4-7 Important Exposure Pathways Identified for the 12 Radionuclides Selected in the Building Occupancy Scenario

Radionuclide	External	Inhalation	External Exposure from Deposition	Immersion	Ingestion	Radon
C-14					X	
Co-60	X	X	X		X	
Cs-137			X		X	
H-3		X			X	
I-129					X	
Np-237		X			X	
Pu-239		X			X	
Ra-226					X	
Ra-228		X			X	X
Sr-90		X			X	
Tc-99					X	
U-238		X			X	
Note: “X” indicates important exposure pathway contributing in the dose variability.						

Table 4-8 Parameters with High Correlation with Dose for the Building Occupancy Scenario

Parameter to Which the Peak Total Dose Is Sensitive	C-14	Co-60	Cs-137	H-3	I-129	Np-237	Pu-239	Ra-226	Ra-228	Sr-90	Tc-99	U-238
Deposition velocity	++	+++	+++	+++	++	++	++	-	---	++	+++	+
Resuspension rate	---	---	---	---	---	--	--	---		---	---	--
Release time of source 1		++	+	--	–	---	---	–	–	--	---	---
Release time of source 2			+	--	–	---	---	–	–	--	--	---
Release time of source 3		–		–		–	–			–	–	--
Release time of source 4		–		–		–	–			–	–	--
Release time of source 5		–		–		--	--			–	--	--
Release time of source 6				–		–	–			–	–	--

The influence of a parameter is categorized subjectively in to three groups: those with standardized rank regression coefficient (SRRC) >0.4 are shown with +++ or ---; those with an SRRC in the range ≥0.2 to 0.4 are shown with ++ or --; and those with an SRRC in the range ≥0.1 to <0.2 are shown with + or -. Symbol “+” is used when an increase in the parameter value increases dose, and symbol “−“is used when an increase in the parameter value decreases dose.

Table 4-9 Effect of Parameters Contributing Significantly to Pathway Doses for the Building Occupancy Scenario

Parameter	Effect	Significance	Comment
Deposition velocity	Deposition rate of particulates in air	Surface concentration, air concentration	Deposition rate in the room depends on the deposition velocity. The surface contamination due to deposition is directly proportional to deposition velocity and air concentration and inversely proportional to resuspension rate. Higher deposition velocity coupled with higher air concentration and low resuspension rate results in higher surface contamination. The surface contamination calculates ingestion pathway dose directly from the deposited materials and the external pathway dose from deposited material.
Resuspension rate	Material deposited on the surface that is resuspended in air		
Release time of source/source lifetime	Release rate	Air concentration	The release rate of radionuclides in the room is inversely proportional to the source lifetime. The shorter source lifetime increases the release rate. Air concentration in the room is directly proportional to the release rate. The higher release rate increases radionuclide concentration in the room.

4.3 Offsite Resident Scenario via Water Transport

Section B.3 in Appendix B provides the details of the analysis for the Offsite Resident Scenario via Water Transport. Table B-42 lists the input parameters of the RESRAD-OFFSITE code, their base value used in the deterministic calculations, and their statistical distribution (including the distribution function and the associated distribution parameters) used in the probabilistic calculations. Hydraulic conductivity of contaminated zone and unsaturated zone was set at the code default to avoid water ponding. Table B-43 through B-54 list the reported results for the Offsite Resident Scenario via Water Transport scenario for each of the 12 radionuclides selected for evaluation. In the probabilistic analysis, there is a distribution of peak total dose and distribution of peak pathway doses from different simulations. Pathways that contribute significantly to the total dose depend on the radionuclide at the dose percentile selected. Dominant exposure pathways at 50 percent and 95 percent are highlighted in Table B-43 through B-54. Table B-55 lists dominant exposure pathways for 50 percent and 95 percent dose percentiles. The dominant exposure pathways are defined as pathways that contribute more than 5 percent to the total dose.

Table 4-10 lists the peak dose distribution with probabilistic calculation for all radionuclides analyzed in the Offsite Resident Scenario via Water Transport. The peak dose-to-source ratio (mrem/yr per pCi/g) at 95 percent varied from 3.6E-07 (H-3) to 17.3 (Ra-226). The relative variability in dose distribution captured by the ratio of peak dose at 95 percent to 50 percent (listed in last row of Table 4-10) was small for C-14 (18) and large for Co-60 (4600). For other radionuclides, relative variability ranged from >18 to <4600. Table 4-11 lists important exposure pathways identified that contribute to peak total dose variability for the 12 radionuclides selected in the Offsite Resident Scenario via Water Transport.

Table 4-12 lists parameters (a total of 33) associated with each radionuclide with a significant effect (SRRC ≥0.05) on dose for the Offsite Resident Scenario via Water Transport. The parameters with a significant effect on dose depend on the dominant exposure pathways and their variability in dose distribution. Table 4-13 lists the effect and significance of parameters in the dose assessment for the Offsite Resident Scenario via Water Transport.

Table 4-10 Distribution of Peak Total Dose Obtained with Probabilistic Calculations in the Offsite Resident Scenario via Water Transport for Different Radionuclides Analyzed (mrem/yr per pCi/g)

Percentile	C-14	Co-60	Cs-137	H-3	I-129	Np-237	Pu-239	Ra-226	Ra-228	Sr-90	Tc-99	U-238
5	2.74E-04	0.00E+00	0.00E+00	0.00E+00	3.54E-07	5.27E-10	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.59E-09	0.00E+00
10	3.55E-04	0.00E+00	0.00E+00	8.68E-15	1.10E-05	6.20E-06	3.29E-06	3.44E-05	0.00E+00	0.00E+00	7.64E-08	4.24E-07
15	4.25E-04	2.22E-20	7.67E-09	4.36E-12	3.81E-05	3.34E-05	9.99E-05	1.98E-03	3.81E-15	1.05E-08	2.72E-07	1.64E-05
20	4.78E-04	4.75E-13	1.40E-07	2.69E-11	9.03E-05	8.62E-05	3.71E-04	8.18E-03	1.69E-09	1.22E-07	7.16E-07	5.16E-05
25	5.38E-04	5.54E-12	4.68E-07	7.52E-11	1.81E-04	1.72E-04	8.10E-04	1.96E-02	1.22E-08	4.17E-07	1.70E-06	1.18E-04
30	5.97E-04	2.06E-11	1.03E-06	1.57E-10	3.40E-04	2.99E-04	1.59E-03	3.51E-02	4.31E-08	8.63E-07	3.38E-06	2.16E-04
35	6.60E-04	5.54E-11	2.02E-06	2.68E-10	6.66E-04	4.87E-04	2.75E-03	6.33E-02	1.02E-07	1.61E-06	6.53E-06	3.89E-04
40	7.25E-04	1.29E-10	3.37E-06	4.51E-10	1.12E-03	7.85E-04	4.39E-03	1.03E-01	2.29E-07	2.69E-06	1.27E-05	5.84E-04
45	7.95E-04	2.94E-10	5.45E-06	7.37E-10	1.99E-03	1.19E-03	7.07E-03	1.53E-01	4.84E-07	4.16E-06	2.62E-05	8.78E-04
50	8.77E-04	7.37E-10	8.30E-06	1.17E-09	3.61E-03	1.85E-03	1.12E-02	2.33E-01	1.05E-06	6.46E-06	6.04E-05	1.34E-03
55	9.87E-04	1.68E-09	1.26E-05	1.91E-09	6.85E-03	2.80E-03	1.67E-02	3.49E-01	2.33E-06	9.51E-06	1.35E-04	2.03E-03
60	1.11E-03	3.50E-09	1.87E-05	3.07E-09	1.34E-02	4.16E-03	2.47E-02	5.11E-01	4.78E-06	1.37E-05	3.38E-04	2.85E-03
65	1.29E-03	8.62E-09	2.89E-05	4.89E-09	2.78E-02	6.36E-03	3.55E-02	7.44E-01	1.05E-05	2.11E-05	8.04E-04	4.15E-03
70	1.55E-03	1.95E-08	4.30E-05	8.38E-09	5.36E-02	9.98E-03	5.29E-02	1.06E+00	2.30E-05	3.10E-05	1.73E-03	6.14E-03
75	1.96E-03	4.53E-08	6.62E-05	1.45E-08	1.02E-01	1.57E-02	7.88E-02	1.60E+00	4.91E-05	4.90E-05	3.48E-03	9.03E-03
80	2.72E-03	1.05E-07	1.01E-04	2.48E-08	2.01E-01	2.63E-02	1.22E-01	2.55E+00	1.08E-04	7.52E-05	6.11E-03	1.40E-02
85	4.13E-03	2.51E-07	1.66E-04	4.72E-08	3.89E-01	4.84E-02	2.08E-01	4.12E+00	2.50E-04	1.31E-04	1.04E-02	2.24E-02
90	6.86E-03	7.09E-07	3.17E-04	1.10E-07	7.96E-01	8.95E-02	3.84E-01	7.35E+00	6.46E-04	2.52E-04	1.75E-02	3.89E-02
95	1.56E-02	3.36E-06	7.54E-04	3.60E-07	1.84E+00	2.09E-01	9.60E-01	1.73E+01	2.99E-03	5.64E-04	3.07E-02	8.89E-02
Max	2.69E+00	2.57E-04	4.12E-02	2.18E-05	2.20E+01	5.20E+00	2.55E+01	4.78E+02	2.66E-01	4.04E-02	1.34E-01	4.34E+01
Mean	5.77E-03	1.16E-06	2.30E-04	1.32E-07	3.59E-01	4.57E-02	2.35E-01	4.02E+00	9.92E-04	1.48E-04	5.18E-03	6.17E-02
Ratio (95/50)	1.77E+01	4.56E+03	9.09E+01	3.08E+02	5.09E+02	1.13E+02	8.59E+01	7.39E+01	2.84E+03	8.72E+01	5.08E+02	6.62E+01

Table 4-11 Important Exposure Pathways Identified for the 12 Radionuclides Selected in the Offsite Resident Scenario via Water Transport

Radionuclides	Water Release					
	Fish Ingestion	Plant Ingestion	Meat Ingestion	Milk Ingestion	Soil Ingestion	Water Ingestion
C-14	X					
Co-60	X	X				X
Cs-137	X					
H-3		X	X	X		X
I-129		X	X	X		X
Np-237	X	X	X			X
Pu-239	X					
Ra-226	X					
Ra-228	X					
Sr-90	X	X		X		X
Tc-99		X		X		X
U-238			X			

	CZ and Air Release			
	Plant Ingestion	Meat Ingestion	Milk Ingestion	Soil Ingestion
C-14				
Co-60				
Cs-137				
H-3				
I-129				
Np-237				
Pu-239				
Ra-226				
Ra-228				
Sr-90	X			
Tc-99				
U-238		X		

Note: "X" indicates important exposure pathway contributing in the peak total dose variability.
Note: "CZ and Air Release" represents dose directly from primary contamination and from release to atmosphere.

Table 4-12 Parameters with High Correlation with Dose for the Offsite Resident Scenario via Water Transport

Parameter to Which the Peak Total Dose Is Sensitive	C-14	Co-60	Cs-137	H-3	I-129	Np-237	Pu-239	Ra-226	Ra-228	Sr-90	Tc-99	U-238
Cover and management factor in area of primary contamination	+++	+	+++	+++	+++	+++	+++	+++	+++	+++	+++	+++
Slope-length-steepness factor in area of primary contamination	+++	+	+									
Rainfall and runoff factor in area of primary contamination	+++		+	++				+				
Dry bulk density of cover	–	+++	+++			+++		++	++			++
Soil erodibility factor of cover	+		---	---	---	---	---	---	---	---	---	--
Depth of soil mixing layer in area of primary contamination	+++			–								
Thickness of cover	---			+								
Runoff coefficient of catchment area	--			–				–				
Deposition velocity of all particulates to compute atmospheric release				–							+	
Mass loading of all particulates									+			
Deposition velocity of all radionuclide particulates							+					
Hydraulic gradient of saturated zone to well												
Hydraulic conductivity of saturated zone			+	+								
Total porosity of saturated zone			+		+							++
Effective porosity of saturated zone				–								

The influence of a parameter is categorized subjectively in to three groups: those with standardized rank regression coefficient (SRRC) >0.2 are shown with +++ or ---; those with an SRRC in the range ≥0.1 to 0.2 are shown with ++ or --; and those with an SRRC in the range ≥0.05 to <0.1 are shown with + or -. Symbol "+" is used when an increase in the parameter value increases dose, and symbol "–"is used when an increase in the parameter value decreases dose.

Table 4-12 Parameters with High Correlation with Dose for the Offsite Resident Scenario via Water Transport (cont.)

Parameter to Which the Peak Total Dose Is Sensitive	C-14	Co-60	Cs-137	H-3	I-129	Np-237	Pu-239	Ra-226	Ra-228	Sr-90	Tc-99	U-238
Distance in the direction parallel to aquifer flow from downgradient edge of contamination			++		++		+					
Longitudinal dispersivity of saturated zone to well			++		+++				+	+	+	+++
K_d in saturated zone		+	+++		+++	+++	+++	+++	+++	+++	+++	+++
K_d in unsaturated zone								++				
Thickness of unsaturated zone						–						
Cover and management factor of catchment area					++							
Slope-length-steepness factor of catchment area					+							
Fraction of eroded radionuclides deposited in the surface water body					--	–						
First time at which release begins	+			--								
Water to aquatic food transfer factor for fish	+++	+	+++	+++	+++	+++	+++	+++	+++	+++	+++	+++
Soil to plant transfer factor for fruit, grain, nonleafy vegetables		+	+									
Intake to animal product transfer factor for meat			+	++				+				
Intake to animal product transfer factor for milk		+++	+++			+++		++	++			++
Irrigation applied per year to pasture and silage field			---	---	---	---	---	---	---	---	---	--
Dry bulk density of contaminated zone	++			–								
Thickness of contaminated zone	+				+						+	

The influence of a parameter is categorized subjectively in to three groups: those with standardized rank regression coefficient (SRRC) >0.2 are shown with +++ or ---; those with an SRRC in the range ≥0.1 to 0.2 are shown with ++ or --; and those with an SRRC in the range ≥0.05 to <0.1 are shown with + or -. Symbol "+" is used when an increase in the parameter value increases dose, and symbol "−"is used when an increase in the parameter value decreases dose.

Table 4-12 Parameters with High Correlation with Dose for the Offsite Resident Scenario via Water Transport (cont.)

Parameter to Which the Peak Total Dose Is Sensitive	C-14	Co-60	Cs-137	H-3	I-129	Np-237	Pu-239	Ra-226	Ra-228	Sr-90	Tc-99	U-238
C-14 evasion flux rate from soil	++											
Evapotranspiration coefficient in area of primary contamination				–								

The influence of a parameter is categorized subjectively in to three groups: those with standardized rank regression coefficient (SRRC) >0.2 are shown with +++ or ---; those with an SRRC in the range ≥0.1 to 0.2 are shown with ++ or --; and those with an SRRC in the range ≥0.05 to <0.1 are shown with + or -. Symbol "+" is used when an increase in the parameter value increases dose, and symbol "−"is used when an increase in the parameter value decreases dose.

Table 4-13 Effect of Parameters Contributing Significantly to Pathway Doses for the Offsite Resident Scenario via Water Transport

Effect	Significance	Contributing Parameters	Comments
Surface water concentration material availability for atmospheric release	All pathways	Cover and management factor. Slope-length-steepness factor. Rainfall and runoff factor. Soil erodibility factor of cover. Bulk density of cover.	The cover and management factor in area of primary contamination, the slope-length-steepness factor in area of primary contamination, the rainfall and runoff factor in area of primary contamination, bulk density and the soil erodibility factor compute the erosion rate.
		Depth of soil mixing layer. Thickness of cover.	The depth of soil mixing layer, the thickness of the cover, and the erosion rate determine (1) the rate of erosion release to runoff that eventually runs into the surface water body, and (2) the rate at which the material from the primary contamination enters the mixing layer and is available to be released into the atmosphere. The initial thickness of the cover and the erosion rate also determine the evasion of C-14 and H-3, and the diffusion of the radon isotopes.
Surface water concentration	All surface water release pathways	Runoff coefficient of catchment area	The runoff coefficient of catchment area is used to compute the amount of precipitation on the catchment that reaches the surface water body.
Air concentration	All pathways	Mass loading. Deposition velocity of all particulates	The deposition velocity of all particulates and mass loading is used to compute atmospheric release.
Offsite radionuclide concentration	All pathways	Deposition velocity of all particulates containing radionuclides	A higher deposition velocity leads to greater deposition of the radionuclides at nearby offsite locations, but can also lead to lower deposition further away due to depletion of the plume.

Table 4-13 Effect of Parameters Contributing Significantly to Pathway Doses for the Water Transport Scenario (cont.)

Effect	Significance	Contributing Parameters	Comments
Ground water concentration	Water release pathways	Hydraulic gradient of saturated zone to well. Hydraulic conductivity of saturated zone. Total porosity of saturated zone. Effective porosity of saturated zone. Distance in the direction parallel to aquifer flow from downgradient edge of contamination. Longitudinal dispersivity of saturated zone to well. K_d in saturated zone.	A faster transport rate allows radionuclides from the far end of the primary contamination to reach the well before the flow of radionuclides from the near end decreases appreciably.
Ground water concentration	Water release pathways	Thickness of unsaturated zone. K_d in unsaturated zone.	The distribution coefficient in unsaturated zone and the thickness of unsaturated zone determine the transport of the radionuclides in the unsaturated zone.
Surface water concentration	All surface water release pathways	Cover and management factor of catchment area. Slope-length-steepness factor of catchment area.	The cover and management factor of catchment area and the slope-length-steepness factor of catchment area determine the quantity of sediments that are eroded from the catchment.
Surface water concentration	All surface water release pathways	Fraction of eroded radionuclides deposited in the surface water body.	The fraction of eroded radionuclides deposited in the surface water body determines the amount of radionuclides deposited in the surface water body.
Inventory of short-lived radionuclides available for release	All pathways	1st time at which release begins.	The first time at which release begins in conjunction with the erosion rate of the cover also affects the thickness of the cover at the time the release commences, reducing the thickness of the cover through which gaseous forms of radionuclides diffuse out of the primary contamination and increasing the thickness of the primary contamination from which the nuclides are released.
Fish concentration	Fish ingestion pathway	Water to aquatic food transfer facto.r	Higher water-to-animal aquatic food transfer factor increases fish pathway dose.
Plant concentration	Plant, meat, milk ingestion pathway	Soil to plant transfer factor.	Higher soil-to-plant transfer factor increases plant, meat, and milk ingestion pathway doses.
Meat concentration	Meat ingestion pathway	The intake-to-animal product transfer factor for meat.	Higher intake-to-animal product transfer factor for meat increases meat pathway dose.
Pasture and silage concentration	Meat and milk pathway	Irrigation applied to pasture and silage field	Higher irrigation applied to pasture and silage field increases meat and milk pathway doses.
Radionuclide total inventory in the contaminated zone	All pathways	Dry bulk density of contaminated zone. Thickness of contaminated zone.	The dry bulk density of contaminated zone and the thickness of the contaminated zone influence the inventory of the radionuclides in the contaminated zone of fixed dimension.

Table 4-13 Effect of Parameters Contributing Significantly to Pathway Doses for the Water Transport Scenario (cont.)

Effect	Significance	Contributing Parameters	Comments
C-14 air concentration	C-14 dose	C-14 evasion flux rate from soil.	The C-14 evasion flux rate from soil determines the rate at which C-14 is released into the atmosphere.
H-3 air concentration	Amount of H-3 in air and food products	Evapotranspiration coefficient in area of primary contamination.	The evapotranspiration coefficient in area of primary contamination along with other parameters determines the H-3 release in air.

4.4 Offsite Resident Scenario via Air Transport

The Offsite Resident Scenario via Air Transport considers all exposure pathways including radon inhalation. The source has no cover. Release from the surface layer begins at time zero. Release to groundwater occurs after a delay of 100 years. Release mechanism is instantaneous equilibrium desorption release. The groundwater well and surface water body are downgradient. The groundwater also discharges to surface water body. This scenario assumes that 100 percent water use is from the surface water. In the analysis, physical parameters have a distribution. In the case of physical parameters for which distributions are available, those are used; for other physical parameters without distributions, those were based on judgment.

Section B.4 in Appendix B provides the details of the analysis for the Offsite Resident Scenario via Air Transport. Table B-57 lists the input parameters of the RESRAD-OFFSITE code, their base value used in the deterministic calculations, and their statistical distribution (including the distribution function and the associated distribution parameters) used in the probabilistic calculations. Radionuclide- or element-specific input parameters are listed in separate tables. Hydraulic conductivity of contaminated zone and unsaturated zone was set at the code default to avoid water ponding. Table B-58 through B-69 list the reported results for the Offsite Resident Scenario via Air Transport for each of the 12 radionuclides selected for evaluation. Pathways that contribute significantly to the total dose depend on the radionuclide at the dose percentile selected. Dominant exposure pathways at 50 percent and 95 percent are highlighted in Table B-58 through B-69. Table B-70 lists dominant exposure pathways for 50 percent and 95 percent dose percentiles. The dominant exposure pathways are defined as pathways that contribute more than 5 percent to the total dose.

Table 4-14 lists the peak total dose distribution obtained with probabilistic calculations for all radionuclides analyzed in the Offsite Resident Scenario via Air Transport. The peak dose-to-source ratio (mrem/yr per pCi/g) at 95 percent varied from 8.9E-04 (Tc-99) to 41.8 (Ra-226). The relative variability in dose distribution captured by the ratio of peak dose at 95 percent to 50 percent (listed in last row of Table 4-14) was small for Co-60 (1.0), Ra-228 (1.7), H-3 (1.8), and Cs-137 (2.3) and >9 for other radionuclides. Table 4-15 lists important exposure pathways identified that contribute to peak total dose variability for the 12 radionuclides selected in the Offsite Resident Scenario via Air Transport analysis.

Table 4-16 lists parameters (a total of 40) associated with each radionuclide with a significant effect (SRRC ≥0.05) on dose for the Offsite Resident Scenario via Air Transport. The parameters with a significant effect on dose depend on the dominant exposure pathways and their variability in dose distribution. Table 4-17 lists the effect and significance of parameters in the dose assessment for the Offsite Resident Scenario via Air Transport.

Table 4-14 Distribution of Peak Total Dose Obtained with Probabilistic Calculations in the Offsite Resident Scenario via Air Transport for Different Radionuclides Analyzed (mrem/yr per pCi/g)

Percentile	C-14	Co-60	Cs-137	H-3	I-129	Np-237	Pu-239	Ra-226	Ra-228	Sr-90	Tc-99	U-238
5	1.31E-03	3.81E-02	9.35E-03	3.59E-03	2.78E-05	3.07E-03	5.75E-04	7.58E-01	5.59E-01	1.17E-04	6.40E-07	4.92E-04
10	1.49E-03	3.81E-02	9.35E-03	4.18E-03	5.96E-05	3.43E-03	1.29E-03	1.02E+00	6.43E-01	1.21E-04	9.31E-07	5.51E-04
15	1.63E-03	3.81E-02	9.35E-03	4.67E-03	1.08E-04	3.69E-03	1.83E-03	1.29E+00	7.09E-01	1.27E-04	1.31E-06	5.90E-04
20	1.76E-03	3.81E-02	9.35E-03	5.07E-03	1.82E-04	3.95E-03	2.26E-03	1.52E+00	7.63E-01	1.39E-04	1.86E-06	6.28E-04
25	1.88E-03	3.81E-02	9.35E-03	5.49E-03	2.73E-04	4.20E-03	2.71E-03	1.75E+00	8.17E-01	1.54E-04	2.58E-06	6.63E-04
30	1.98E-03	3.81E-02	9.36E-03	5.86E-03	4.04E-04	4.50E-03	3.15E-03	1.96E+00	8.66E-01	1.74E-04	3.70E-06	6.99E-04
35	2.10E-03	3.81E-02	9.36E-03	6.19E-03	5.58E-04	4.84E-03	3.66E-03	2.24E+00	9.11E-01	2.00E-04	5.26E-06	7.43E-04
40	2.21E-03	3.81E-02	9.37E-03	6.53E-03	7.85E-04	5.25E-03	4.21E-03	2.54E+00	9.55E-01	2.40E-04	7.33E-06	7.95E-04
45	2.34E-03	3.81E-02	9.38E-03	6.87E-03	1.08E-03	5.82E-03	4.86E-03	2.83E+00	1.00E+00	2.87E-04	1.02E-05	8.60E-04
50	2.47E-03	3.81E-02	9.40E-03	7.25E-03	1.49E-03	6.57E-03	5.65E-03	3.15E+00	1.05E+00	3.47E-04	1.37E-05	9.46E-04
55	2.63E-03	3.81E-02	9.42E-03	7.63E-03	1.95E-03	7.48E-03	6.75E-03	3.62E+00	1.09E+00	4.34E-04	1.87E-05	1.05E-03
60	2.79E-03	3.81E-02	9.45E-03	8.08E-03	2.55E-03	8.78E-03	8.16E-03	4.05E+00	1.15E+00	5.48E-04	2.49E-05	1.18E-03
65	3.02E-03	3.81E-02	9.51E-03	8.55E-03	3.56E-03	1.05E-02	9.99E-03	4.71E+00	1.20E+00	6.94E-04	3.61E-05	1.38E-03
70	3.38E-03	3.81E-02	9.61E-03	9.05E-03	4.75E-03	1.29E-02	1.29E-02	5.49E+00	1.26E+00	9.07E-04	5.15E-05	1.63E-03
75	3.96E-03	3.81E-02	9.87E-03	9.55E-03	6.63E-03	1.59E-02	1.67E-02	6.76E+00	1.33E+00	1.21E-03	7.68E-05	2.04E-03
80	4.95E-03	3.82E-02	1.03E-02	1.02E-02	9.43E-03	2.14E-02	2.25E-02	8.88E+00	1.40E+00	1.71E-03	1.17E-04	2.61E-03
85	6.66E-03	3.82E-02	1.12E-02	1.08E-02	1.38E-02	2.92E-02	3.19E-02	1.25E+01	1.49E+00	2.53E-03	1.94E-04	3.62E-03
90	1.08E-02	3.84E-02	1.36E-02	1.17E-02	2.31E-02	4.45E-02	4.94E-02	2.03E+01	1.61E+00	4.17E-03	3.70E-04	5.56E-03
95	2.27E-02	3.88E-02	2.11E-02	1.31E-02	4.98E-02	8.61E-02	1.04E-01	4.18E+01	1.82E+00	9.01E-03	8.86E-04	1.23E-02
Max	3.09E+00	1.49E-01	8.13E-01	2.21E-02	6.34E+00	7.50E+00	1.32E+01	1.37E+03	1.17E+02	5.68E-01	2.89E-02	5.68E-01
Mean	7.92E-03	3.83E-02	1.21E-02	7.68E-03	1.33E-02	2.62E-02	3.06E-02	1.18E+01	1.14E+00	2.39E-03	2.03E-04	3.47E-03
Ratio (95/50)	9.19E+00	1.02E+00	2.25E+00	1.80E+00	3.35E+01	1.31E+01	1.84E+01	1.33E+01	1.73E+00	2.59E+01	6.47E+01	1.30E+01

Table 4-15 Important Exposure Pathways Identified for the 12 Radionuclides Selected in the Offsite Resident Scenario via Air Transport

Radionuclides	Water Release							
	External Ground	Fish Ingestion	Radon	Plant Ingestion	Meat Ingestion	Milk Ingestion	Soil Ingestion	Water Ingestion
C-14		X						
Co-60	X	X		X				X
Cs-137		X			X			
H-3								
I-129		X		X	X	X		X
Np-237		X		X				X
Pu-239		X		X				X
Ra-226		X						
Ra-228		X						
Sr-90		X		X		X		X
Tc-99		X		X		X		X
U-238		X		X		X		X

	Contaminated Zone and Air						
	External Ground	Inhalation	Radon	Plant Ingestion	Meat Ingestion	Milk Ingestion	Soil Ingestion
C-14							
Co-60	X			X			
Cs-137							
H-3		X					
I-129							
Np-237							
Pu-239							
Ra-226			X				
Ra-228			X				
Sr-90				X			
Tc-99							
U-238	X						

Note: "X" indicates important exposure pathway contributing in the peak total dose variability.

Table 4-16 Parameters with High Correlation with Dose for the Offsite Resident Scenario via Air Transport

Parameter to Which the Peak Total Dose Is Sensitive	C-14	Co-60	Cs-137	H-3	I-129	Np-237	Pu-239	Ra-226	Ra-228	Sr-90	Tc-99	U-238
Cover and management factor in area of primary contamination	+++	+	+++	+++	+++	+++	+++	+++	+++	+++	+++	+++
Slope-length-steepness factor in area of primary contamination	+++	+	+									
Rainfall and runoff factor in area of primary contamination	+++		+	++				+				
Soil erodibility factor of contaminated zone	++	+++	+++			+++		++	++			++
Support practice factor in area of primary contamination			---	---	---	---	---	---	---	---	---	--
Deposition velocity of all particulates to compute atmospheric release				–								
Mass loading of all particulates				+								
Deposition velocity of respirable particulates				–				–				
Deposition velocity of all particulates				–							+	
Hydraulic gradient of saturated zone to surface water body									+			
Hydraulic conductivity of saturated zone							+					
Distance in the direction parallel to aquifer flow from downgradient edge of contamination												
K_d in saturated zone			+	+								
Cover and management factor of catchment area			+		+							++

The influence of a parameter is categorized subjectively in to three groups: those with standardized rank regression coefficient (SRRC) >0.2 are shown with +++ or ---; those with an SRRC in the range ≥0.1 to 0.2 are shown with ++ or --; and those with an SRRC in the range ≥0.05 to <0.1 are shown with + or -. Symbol "+" is used when an increase in the parameter value increases dose, and symbol "–" is used when an increase in the parameter value decreases dose.

Table 4-16 Parameters with High Correlation with Dose for the Offsite Resident Scenario via Air Transport (cont.)

Parameter to Which the Peak Total Dose Is Sensitive	C-14	Co-60	Cs-137	H-3	I-129	Np-237	Pu-239	Ra-226	Ra-228	Sr-90	Tc-99	U-238
Soil erodibility factor of catchment area				–								
Slope-length-steepness factor of catchment area						–	--	--		–		–
Runoff coefficient of catchment area	--				--	--	--	--		--	--	--
K_d in bottom sediment in surface water body	--	---	---			–	--	+	--	–		--
Thickness of bottom sediment layer in adsorption/desorption equilibrium of radionuclides with water		–	–					+				
Density of bottom sediment			–									
Water-to-aquatic food transfer factor for fish	+++		++									
Soil-to-plant transfer factor for fruit, grain, nonleafy vegetables										+	+	
Intake-to-animal product transfer factor for milk					++							++
Intake-to-animal product transfer factor for meat			+		++							
Irrigation applied per year to pasture and silage field					+							
Dry bulk density of contaminated zone	+++			+++				++	+++			
Thickness of contaminated zone	+++			++				+				
C-14 evasion flux rate from soil	++											
Thickness of evasion layer for C-14 in soil	++											
Mass fraction of C-12 in atmosphere	–											

The influence of a parameter is categorized subjectively in to three groups: those with standardized rank regression coefficient (SRRC) >0.2 are shown with +++ or ---; those with an SRRC in the range ≥0.1 to 0.2 are shown with ++ or --; and those with an SRRC in the range ≥0.05 to <0.1 are shown with + or -. Symbol "+" is used when an increase in the parameter value increases dose, and symbol "−" is used when an increase in the parameter value decreases dose.

Table 4-16 Parameters with High Correlation with Dose for the Offsite Resident Scenario via Air Transport (cont.)

Parameter to Which the Peak Total Dose Is Sensitive	C-14	Co-60	Cs-137	H-3	I-129	Np-237	Pu-239	Ra-226	Ra-228	Sr-90	Tc-99	U-238
Mass fraction of C-12 in fruit, grain, nonleafy vegetables	+											
Runoff coefficient in area of primary contamination				---								
Evapotranspiration coefficient in area of primary contamination				+++								
Irrigation applied per year in area of primary contamination				+++								
K_d in contaminated zone				---								
Total porosity of contaminated zone				--								
b parameter of contaminated zone				–								
Radon emanation coefficient								+++	+++			
Building air exchange rate								---				
Effective radon diffusion coefficient								++	+++			

The influence of a parameter is categorized subjectively in to three groups: those with standardized rank regression coefficient (SRRC) >0.2 are shown with +++ or ---; those with an SRRC in the range ≥0.1 to 0.2 are shown with ++ or --; and those with an SRRC in the range ≥0.05 to <0.1 are shown with + or -. Symbol “+” is used when an increase in the parameter value increases dose, and symbol “−“ is used when an increase in the parameter value decreases dose.

Table 4-17 Effect of Parameters Contributing Significantly to Pathway Doses for the Offsite Resident Scenario via Air Transport

Effect	Significance	Contributing Parameters	Comments
Surface water concentration material availability for atmospheric release	All pathways	Cover and management factor. Slope length steepness factor. Rainfall and runoff factor. Soil erodibility factor. Support practice factor.	The cover and management factor in area of primary contamination, the slope-length-steepness factor in area of primary contamination, the rainfall and runoff factor in area of primary contamination, the soil erodibility factor, and support practice factor compute the erosion rate.
Air concentration	All pathways	Mass loading. Deposition velocity of all particulates.	The deposition velocity of all particulates and mass loading is used to compute atmospheric release.
Offsite radionuclide concentration	All pathways	Deposition velocity of all particulates containing radionuclides.	A higher deposition velocity leads to greater deposition of the radionuclides at nearby offsite locations, but can also lead to lower deposition farther away due to depletion of the plume.
Offsite respirable radionuclide concentration	Inhalation pathways	Deposition velocity of respirable particulates.	A higher deposition velocity leads to greater deposition of the radionuclides at nearby offsite locations, but can also lead to lower deposition farther away due to depletion of the plume.
Water concentration	Water release pathways	Hydraulic gradient of saturated zone to surface water body. Hydraulic conductivity of saturated zone. Distance in the direction parallel to aquifer flow from downgradient edge of contamination. K_d in saturated zone	A faster transport rate allows radionuclides from the far end of the primary contamination to reach the surface water body before the flow of radionuclides from the near end decreases appreciably.
Surface water concentration	All surface water release pathways	Cover and management factor of catchment area. Slope-length-steepness factor of catchment area. Soil erodibility factor of catchment area	The cover and management factor of catchment area, the slope-length-steepness factor of catchment area, and soil erodibility factor of catchment area determine the quantity of sediments that are eroded from the catchment.
Surface water concentration	All surface water release pathways	Runoff coefficient of catchment area	The runoff coefficient of catchment area is used to compute the amount of precipitation on the catchment that reaches the surface water body.

Table 4-17 Effect of Parameters Contributing Significantly to Pathway Doses for the Offsite Resident Scenario via Air Transport (cont.)

Effect	Significance	Contributing Parameters	Comments
Surface water concentration	All surface water release pathways	K_d in bottom sediment in surface water body Thickness of bottom sediment layer in adsorption/desorption equilibrium of radionuclides with water Density of bottom sediment	The K_d in bottom sediment in surface water body, thickness of bottom sediment layer, density of bottom sediment, and runoff coefficient of catchment area determine the water concentration.
Fish concentration	Fish ingestion pathway	Water-to-aquatic food transfer factor	Higher water-to-animal aquatic food transfer factor increases fish pathway dose.
Plant concentration	Plant, meat, milk ingestion pathway	Soil-to-plant transfer factor	Higher soil-to-plant transfer factor increases plant, meat, and milk ingestion pathway doses.
Meat concentration	Meat ingestion pathway	The intake-to-animal product transfer factor for meat	Higher intake-to-animal product transfer factor for meat increases meat pathway dose.
Milk concentration	Milk ingestion pathway	The intake-to-animal product transfer factor for milk	Higher intake-to-animal product transfer factor for milk increases milk pathway dose.
Pasture and silage concentration	Meat and milk pathway	Irrigation applied to pasture and silage field	Higher irrigation applied to pasture and silage field increases meat and milk pathway doses.
Radionuclide total inventory in the contaminated zone	All pathways	Dry bulk density of contaminated zone Thickness of contaminated zone	The dry bulk density of contaminated zone and the thickness of the contaminated zone influence the inventory of the radionuclides in the contaminated zone of fixed dimension.
C-14 concentration in air and food products	C-14 dose	C-14 evasion flux rate from soil Thickness of evasion layer for C-14 in soil Mass fraction of C-12 in atmosphere Mass fraction of C-12 in fruit, grain, nonleafy vegetables	The C-14 evasion flux rate from soil determines the rate at which C-14 is released into the atmosphere. The thickness of the evasion layer for C-14 determines the fraction of the inventory that can be released to the atmosphere in gaseous form. Mass fractions of C-12 in atmosphere and fruit, grain, and nonleafy vegetables calculate the C-14 concentration in different media.

Table 4-17 Effect of Parameters Contributing Significantly to Pathway Doses for the Offsite Resident Scenario via Air Transport (cont.)

Effect	Significance	Contributing Parameters	Comments
H-3 concentration in different media	H-3 dose	Evapotranspiration coefficient Runoff coefficient Irrigation K_d *i*n contaminated zone Total porosity of contaminated zone b parameter of contaminated zone	The runoff coefficient in area of primary contamination, the evapotranspiration coefficient in area of primary contamination, the irrigation applied per year in area of primary contamination, the distribution coefficient in contaminated zone, total porosity of contaminated zone, and b parameter of contaminated zone determine the H-3 release in air.
Radon and its short-lived progeny concentration	Radon dose	Radon emanation coefficient Building air exchange rate Effective radon diffusion coefficient	The radon emanation coefficient, the building air exchange rate, and the effective radon diffusion coefficient affect the concentration of radon and its short-lived progeny in air.

5 PARAMETER DISTRIBUTIONS

Table 5-1 lists the parameters with a significant effect on peak total dose for multiple radionuclides in different scenarios based on the probabilistic analyses. The Resident Farmer scenario was analyzed using RESRAD-ONSITE code. The Building Occupancy scenario was analyzed using RESRAD-BUILD code. The Offsite Resident via Water Transport and Offsite Resident via Air Transport scenarios were analyzed using RESRAD-OFFSITE code. Some parameters, such as density of contaminated zone, K_d of saturated zone, and deposition velocity of all particulates, have a significant effect on peak total dose for multiple scenarios and multiple radionuclides. For many parameters with a significant effect on peak total dose, distributions are available from the previous studies.

Table 5-1 Parameters with Significant Effect on Peak Total Dose in Different Scenarios

Parameter with Significant Effect on Peak Total Dose	Scenario3	Distribution Available from Previous Studies
First time at which release begins	Offsite Resident via Water Transport	No
Area of contaminated zone	Resident Farmer	No
Building air exchange rate	Resident Farmer, Offsite Resident via Air Transport	Yes
Building foundation thickness	Resident Farmer	No
Building foundation total porosity	Resident Farmer	Yes
Building room height	Resident Farmer	Yes
C-14 evasion flux rate from soil	Resident Farmer, Offsite Resident via Water Transport, Offsite Resident via Air Transport	No
Contaminated zone b parameter	Resident Farmer, Offsite Resident via Air Transport	Yes
Contaminated zone hydraulic conductivity	Resident Farmer	Yes
Contaminated zone total porosity	Resident Farmer, Offsite Resident via Air Transport	Yes
Cover and management factor in area of primary contamination	Offsite Resident via Water Transport, Offsite Resident via Air Transport	Yes
Cover and management factor of catchment area	Offsite Resident via Water Transport, Offsite Resident via Air Transport	Yes
Density of bottom sediment	Offsite Resident via Air Transport	No
Density of contaminated zone	Resident Farmer, Offsite Resident via Water Transport, Offsite Resident via Air Transport	Yes
Deposition velocity of all particulates	Building Occupancy, Offsite Resident via Water Transport, Offsite Resident via Air Transport	Yes
Deposition velocity of all particulates to compute atmospheric release	Offsite Resident via Water Transport, Offsite Resident via Air Transport	Yes

Table 5-1 Parameters with Significant Effect on Peak Total Dose in Different Scenarios (cont.)

Parameter with Significant Effect on Peak Total Dose	Scenario	Distribution Available from Previous Studies
Deposition velocity of respirable particulates	Offsite Resident via Air Transport	No
Depth of roots	Resident Farmer	Yes
Depth of soil mixing layer in area of primary contamination	Offsite Resident via Water Transport	Yes
Distance in the direction parallel to aquifer flow from downgradient edge of contamination	Offsite Resident via Water Transport, Offsite Resident via Air Transport	No
Dry bulk density of cover	Offsite Resident via Water Transport	Ns
Effective porosity of saturated zone	Resident Farmer, Offsite Resident via Water Transport	Yes
Effective porosity of unsaturated zone	Resident Farmer	Yes
Evapotranspiration coefficient in area of primary contamination	Offsite Resident via Water Transport, Offsite Resident via Air Transport	Yes
External gamma shielding factor	Resident Farmer	Yes
Fraction of eroded radionuclides deposited in the surface water body	Offsite Resident via Water Transport	No
Hydraulic gradient of saturated zone to surface water body	Offsite Resident via Air Transport	Yes
Hydraulic gradient of saturated zone to well	Offsite Resident via Water Transport	Yes
Irrigation applied per year in area of primary contamination	Offsite Resident via Air Transport	No
Irrigation applied per year to pasture and silage field	Offsite Resident via Water Transport, Offsite Resident via Air Transport	No
K_d in bottom sediment in surface water body	Offsite Resident via Air Transport	No
K_d in contaminated zone	Resident Farmer, Offsite Resident via Air Transport	Yes
Livestock fodder intake for milk	Resident Farmer	No
Livestock intake of soil	Resident Farmer	No
Livestock water intake for milk	Resident Farmer	No
Longitudinal dispersivity of saturated zone to well	Offsite Resident via Water Transport	No
Mass fraction of C-12 in atmosphere	Offsite Resident via Air Transport	No
Mass fraction of C-12 in fruit, grain, nonleafy vegetables	Offsite Resident via Air Transport	No
Mass loading of all particulates	Offsite Resident via Water Transport, Offsite Resident via Air Transport	Yes
Meat transfer factor	Resident Farmer, Offsite Resident via Water Transport , Offsite Resident via Air Transport	Yes
Milk transfer factor	Resident Farmer, Offsite Resident via Water Transport, Offsite Resident via Air Transport	Yes
Plant transfer factor	Resident Farmer	Yes
Plant transfer factor for fruit, grain, nonleafy vegetables	Offsite Resident via Water Transport, Offsite Resident via Air Transport	No

Table 5-1 Parameters with Significant Effect on Peak Total Dose in Different Scenarios (cont.)

Parameter with Significant Effect on Peak Total Dose	Scenario	Distribution Available from Previous Studies
Plant transfer factor for progeny	Resident Farmer	Yes
Precipitation	Resident Farmer	None recommended
Radon diffusion coefficient	Resident Farmer, Offsite Resident via Air Transport	No
Rainfall and runoff factor in area of primary contamination	Offsite Resident via Water Transport, Offsite Resident via Air Transport	Yes
Release time or source lifetime	Building Occupancy	Yes
Resuspension rate	Building Occupancy	Yes
Rn-222 emanation coefficient	Resident Farmer, Offsite Resident via Air Transport	No
Runoff coefficient in area of primary contamination	Resident Farmer, Offsite Resident via Air Transport	Yes
Runoff coefficient in catchment area	Offsite Resident via Air Transport	Yes
Runoff coefficient of catchment area	Offsite Resident via Water Transport, Offsite Resident via Air Transport	Yes
Saturated zone hydraulic conductivity	Resident Farmer, Offsite Resident via Water Transport , Offsite Resident via Air Transport	Yes
Saturated zone hydraulic gradient	Resident Farmer	Yes
Slope-length-steepness factor in area of primary contamination	Offsite Resident via Water Transport, Offsite Resident via Air Transport	Yes
Slope-length-steepness factor of catchment area	Offsite Resident via Water Transport, Offsite Resident via Air Transport	Yes
Soil erodibility factor of catchment area	Offsite Resident via Air Transport	Yes
Soil erodibility factor of contaminated zone	Offsite Resident via Air Transport	Yes
Soil erodibility factor of contaminated zone	Offsite Resident via Air Transport	Yes
Soil erodibility factor of cover	Offsite Resident via Water Transport	Yes
Support practice factor in area of primary contamination	Offsite Resident via Air Transport	Yes
Thickness of bottom sediment layer in adsorption/desorption equilibrium of radionuclides with water	Offsite Resident via Air Transport	No
Thickness of contaminated zone	Resident Farmer, Offsite Resident via Water Transport, Offsite Resident via Air Transport	No
Thickness of cover	Offsite Resident via Water Transport	No
Thickness of evasion layer of C-14 in soil	Resident Farmer, Offsite Resident via Air Transport	Yes
Thickness of unsaturated zone	Offsite Resident via Water Transport	Yes

Table 5-1 Parameters with Significant Effect on Peak Total Dose in Different Scenarios (cont.)

Parameter with Significant Effect on Peak Total Dose	Scenario	Distribution Available from Previous Studies
Total porosity of saturated zone	Offsite Resident via Water Transport	Yes
Water to aquatic food transfer factor for fish	Offsite Resident via Water Transport, Offsite Resident via Air Transport	Yes
Wind speed	Resident Farmer	Yes

For the Resident Farmer scenario, the newly identified important parameters with significant effect on peak total dose include area of contaminated zone, building foundation thickness, C-14 evasion flux rate from soil, livestock fodder intake for milk, livestock intake of soil, livestock water intake for milk, precipitation, radon diffusion coefficient, radon emanation coefficient, and thickness of contaminated zone. The area and thickness of contaminated zone and the precipitation rate are very site-specific. The area and thickness of contaminated zone can be easily obtained from measurement, and site-specific precipitation data can be obtained from the nearest weather station (https://www.ncdc.noaa.gov/cdo-web/datatools/normals).

Building Occupancy scenario analysis did not identify any new parameter with significant effect on peak total dose.

For the Offsite Resident Scenario via Water Transport, the newly identified parameters with significant effect on dose include first time at which release begins; C-14 evasion flux rate from soil; distance in the direction parallel to aquifer flow from downgradient edge of contamination to well; dry bulk density of cover; fraction of eroded radionuclides deposited in surface water body; irrigation applied per year to pasture and silage field; longitudinal dispersivity of saturated zone to well; plant transfer factor for fruit, grain, and nonleafy vegetables; and thickness of cover. The first time at which release begins, distance in the direction parallel to aquifer flow to well, and density and thickness of cover depend on the waste type and disposal option selected; for these parameters site-specific values should be used.

For the Offsite Resident Scenario via Air Transport, the new parameters with significant effect on dose include C-14 evasion flux rate from soil; density of bottom sediment; deposition velocity of respirable particulates; distance in the direction parallel to aquifer flow from downgradient edge of contamination to well; irrigation applied per year in area of primary contamination; irrigation applied per year to pasture and silage field; K_d in bottom sediment in surface water body; mass fraction of C-12 in atmosphere; mass fraction of C-12 in fruit, grain, and nonleafy vegetables; plant transfer factor for fruit, grain, and nonleafy vegetables; radon diffusion coefficient; radon emanation coefficient; thickness of bottom sediment layer in adsorption/desorption equilibrium of radionuclides with water; thickness of contaminated zone; and irrigation applied per year in area of primary contamination. The distance in the direction parallel to aquifer flow from downgradient edge of contamination to well and thickness of contaminated zone are very site-specific; a site-specific value should be used. The irrigation applied per year in area of primary contamination and irrigation applied per year to pasture and silage field depend on the site-specific needs of the vegetation grown in the area; a site-specific value should be used.

Based on the new information available in the data collection handbook, parameter distributions have been updated for the following: K_d, plant transfer factor, meat transfer factor, milk transfer factor, fish bioaccumulation factor, building air exchange rate, mass loading for inhalation, depth of roots, and fraction of time spent indoor and outdoor are updated.

The distributions for radon emanation coefficient, effective radon diffusion coefficient, and building foundation thickness are developed in this report. Data are collected for some new parameters (diffusion coefficient, soluble concentration, distribution coefficient of suspended sediment in surface water body, and distribution coefficient of bottom sediment in surface water body).

Radionuclide- and element-specific parameters for which distributions were not available in the past in NUREG-6697 report are added in Appendix C of this report. The parameters in this category include distribution coefficient, plant transfer factor, meat transfer factor, milk transfer factor, and bioaccumulation factors for aquatic organisms.

The livestock fodder intake for milk, livestock intake of soil, and livestock water intake for milk are metabolic parameters. For livestock water intake for milk cow, the data collection handbook (Yu et al. 2015) lists an average value of 115 L/d, rather than the DandD default value of 60 L/d.

Based on this analysis, more data should be collected or distributions should be developed for the following parameters:

- C-14 evasion flux rate from soil,
- Deposition velocity of respirable particulates,
- Fraction of eroded radionuclides deposited in surface water body,
- Thickness of bottom sediment layer in adsorption/desorption equilibrium of radionuclides with water,
- Density of bottom sediment,
- Livestock fodder intake for milk,
- Livestock intake of soil,
- Mass fraction of C-12 in atmosphere,
- Mass fraction of C-12 in fruit, grain.

The plant, meat, and milk transfer factors were identified to have significant effect on peak total dose in different scenarios for multiple radionuclides in this analysis. It would be nice to be able to specify different plant types and different meat/milk types in future code updates.

Appendix C includes parameter distributions for all parameters for which distributions were available in the past, parameters for which distributions are updated, and the new parameters for which distributions are developed.

For presentation, the parameters are grouped into six categories: soil and hydrogeological, meteorological, receptor characteristics, crops and livestock, building characteristics, and source characteristics. The presentation of each parameter distribution identifies the code or codes in which it is used and gives a brief description of the parameter, its units, its assigned distribution, and input data. Table 5-2 lists parameters with available distributions.

Table 5-2 Parameters with Significant Effect on Peak Total Dose in Different Scenarios, Applicable Code, and Assigned Distributions

Parameter	Applicable Code	Type	Assigned Distribution	Section in Appendix C
Soil and Hydrogeological				
Density of soil (g/cm^3)	RESRAD-ONSITE and -OFFSITE	P	Normal	3.1
Total porosity	RESRAD-ONSITE and -OFFSITE	P	Normal	3.2
Effective porosity	RESRAD-ONSITE and -OFFSITE	P	Normal	3.3
Hydraulic conductivity (m/yr)	RESRAD-ONSITE and -OFFSITE	P	Bounded lognormal-n	3.4
Soil b parameter	RESRAD-ONSITE and -OFFSITE	P	Bounded lognormal-n	3.5
Hydraulic gradient	RESRAD-ONSITE and -OFFSITE	P	Bounded lognormal-n	3.6
Unsaturated zone thickness (m)	RESRAD-ONSITE and -OFFSITE	P	Bounded lognormal-n	3.7
Cover and contaminated zone erosion rate (m/yr)	RESRAD-ONSITE	P,B	Continuous logarithmic	3.8
Distribution coefficients (cm^3/g)	RESRAD-ONSITE and -OFFSITE	P	Lognormal-n	3.9
Well pumping rate (m^3/yr)	RESRAD-ONSITE and -OFFSITE	B,P	None recommended	3.10
Well pump intake depth (below water table) (m)	RESRAD-ONSITE and -OFFSITE	P	Triangular	3.11
Depth of soil mixing layer (m)	RESRAD-ONSITE and -OFFSITE	P	Triangular	3.12
Cover depth (m)	RESRAD-ONSITE and -OFFSITE	P	None recommended	3.13

Table 5-2 Parameters with Significant Effect on Peak Total Dose in Different Scenarios, Applicable Code, and Assigned Distributions (cont.)

Parameter	Applicable Code	Type	Assigned Distribution	Section in Appendix C
Soil and Hydrogeological (cont.)				
Cover depth (m)	RESRAD-ONSITE and -OFFSITE	P	None recommended	3.13
Volumetric water content	RESRAD-OFFSITE	P	Continuous linear	3.14
Dispersivity (m)	RESRAD-OFFSITE	P	Continuous linear	3.15
Rainfall erosion index	RESRAD-OFFSITE	P	Continuous linear	3.16
Soil erodibility factor (ton/acre)	RESRAD-OFFSITE	P	Continuous linear	3.17
Slope length-steepness factor	RESRAD-OFFSITE	P	Continuous linear	3.18
Cover and management factor	RESRAD-OFFSITE	P	Continuous linear	3.19
Support practice factor	RESRAD-OFFSITE	P	Continuous linear	3.20
C-14 evasion layer thickness in soil (m)	RESRAD-ONSITE and -OFFSITE	P	Triangular	3.21
Sediment distribution coefficients (cm^3/g)	OFFSITE	P	Lognormal	3.22
Meteorological				
Precipitation rate (m/yr)	RESRAD-ONSITE and -OFFSITE	P	None recommended	4.1
Runoff coefficient	RESRAD-ONSITE and -OFFSITE	P	Uniform	4.2
Evapotranspiration coefficient	ONSITE, OFFSITE	P	Uniform	4.3
Humidity (g/m^3)	RESRAD-ONSITE, -OFFSITE, and -BUILD	P	Lognormal-n, uniform	4.4
Wind speed (m/s)	RESRAD-ONSITE and -OFFSITE	P	Bounded lognormal-n, uniform	4.5

Table 5-2 Parameters with Significant Effect on Peak Total Dose in Different Scenarios, Applicable Code, and Assigned Distributions (cont.)

Parameter	Applicable Code	Type	Assigned Distribution	Section in Appendix C
Meteorological (cont.)				
Mass loading for inhalation and foliar deposition (g/m^3)	RESRAD-ONSITE and -OFFSITE	P,B	Continuous linear, lognormal-n	4.6
Deposition velocity (m/s)	RESRAD-BUILD and -OFFSITE	P	Loguniform	4.7
Receptor				
Inhalation rate (m^3/d)	RESRAD-ONSITE, -OFFSITE, and -BUILD	M,B	Triangular	5.1
Drinking water intake (L/yr)	RESRAD-ONSITE and -OFFSITE	M,B	Lognormal-n	5.2
Milk consumption (L/yr)	RESRAD-ONSITE and -OFFSITE	M,B	Triangular	5.3
Fruit, vegetables, and grain consumption (kg/yr)	RESRAD-ONSITE and -OFFSITE	M,B	Triangular	5.4
Soil ingestion rate (g/yr)	RESRAD-ONSITE and -OFFSITE	M,B	Triangular	5.5
Receptor indirect ingestion rate (m^2/h)	RESRAD-BUILD	B	Loguniform	5.6
Direct ingestion rate (g/h for volume source and 1/h for all other sources)	RESRAD-BUILD	B	None recommended	5.7
Quantity of water for household purposes (L/day)	RESRAD-OFFSITE	B	Lognormal-n	5.8
Indoor fraction	RESRAD-ONSITE, -OFFSITE, and -BUILD	B	Continuous linear	5.9
Outdoor fraction	RESRAD-ONSITE and -OFFSITE	B	Continuous linear	5.10
Crops and Livestock				
Depth of roots (m)	RESRAD-ONSITE and -OFFSITE	P	Uniform	6.1
Duration of the growing season (days)	RESRAD-OFFSITE		Triangular	6.2
Transfer factors for plants	RESRAD-ONSITE and -OFFSITE	P	Lognormal-n	6.3

Table 5-2 Parameters with Significant Effect on Peak Total Dose in Different Scenarios, Applicable Code, and Assigned Distributions (cont.)

Parameter	Applicable Code	Type	Assigned Distribution	Section in Appendix C
Crops and Livestock (cont.)				
Transfer factors for meat [(pCi/kg)/(pCi/d)]	RESRAD-ONSITE and -OFFSITE	P	Lognormal-n	6.4
Transfer factors for milk [(pCi/L)/(pCi/d)]	RESRAD-ONSITE and -OFFSITE	P	Lognormal-n	6.5
Wet-weight crop yields for nonleafy vegetables (kg/m^2)	RESRAD-ONSITE and -OFFSITE	P	Lognormal-n	6.6
Weathering removal constant (1/yr)	RESRAD-ONSITE and -OFFSITE	P	Triangular	6.7
Wet foliar interception fraction for leafy vegetables (kg/m^2)	RESRAD-ONSITE and -OFFSITE	P	Triangular	6.8
Bioaccumulation factors for fish [(pCi/kg)/(pCi/L)]	RESRAD-ONSITE and -OFFSITE	P	Lognormal-n	6.9
Aquatic food contaminated fraction	RESRAD-ONSITE and -OFFSITE	B,P	Triangular	6.10
Building Characteristics				
Indoor dust filtration factor	RESRAD-ONSITE and -OFFSITE	P,B	Uniform	7.1
Resuspension rate (1/s)	RESRAD-BUILD	P,B	Loguniform	7.2
Shielding density (g/cm^3)	RESRAD-ONSITE, -OFFSITE, and -BUILD	P	Uniform	7.3
Air exchange rate for building and room (1/h)	RESRAD-ONSITE, -OFFSITE, and -BUILD	B	Lognormal-n	7.4
Room area (m^2)	RESRAD-BUILD	P	Triangular	7.5
Room height (m)	RESRAD-ONSITE, -OFFSITE, and -BUILD	P	Triangular	7.6
Shielding thickness (cm)	RESRAD-ONSITE, -OFFSITE, and -BUILD	P,B	Triangular	7.7
External gamma shielding/penetration factor	RESRAD-ONSITE and -OFFSITE	P	Bounded lognormal-n	7.8

Table 5-2 Parameters with Significant Effect on Peak Total Dose in Different Scenarios, Applicable Code, and Assigned Distributions (cont.)

Parameter	Applicable Code	Type	Assigned Distribution	Section in Appendix C
Source Characteristics				
Source density, volume source (g/cm^3)	RESRAD-BUILD	P	Uniform	8.1
Source erosion rate, volume source (cm/d)	RESRAD-BUILD	P,B	Triangular	8.2
Removable fraction	RESRAD-BUILD	P,B	Triangular	8.3
Source porosity	RESRAD-ONSITE, -OFFSITE, and -BUILD	P	Uniform	8.4
Air release fraction	RESRAD-BUILD	B	Triangular	8.5
Wet and dry zone thickness (cm)	RESRAD-BUILD	P	Uniform	8.6
Time for source removal or source lifetime (d)	RESRAD-BUILD	P,B	Triangular	8.7
Source thickness, volume source (cm)	RESRAD-BUILD	P	Triangular	8.8
Water fraction available for evaporation	RESRAD-BUILD	P	Triangular	8.9
Radon emanation coefficient	RESRAD-ONSITE, -OFFSITE, and -BUILD	P	Loguniform	8.10
Radon Diffusion coefficient	RESRAD-ONSITE, -OFFSITE, and -BUILD	P	Loguniform	8.11
Soluble concentration of nuclides	RESRAD-OFFSITE	P	None recommended	8.12
Diffusion coefficient of nuclides	RESRAD-OFFSITE	P	None recommended	8.13

6 DEVELOPMENT OF TEMPLATE FILES FOR RESIDENT FARMER AND BUILDING OCCUPANCY SCENARIOS

Template files for conducting deterministic analysis for 12 representative radionuclides, as well as the methodology for selecting the deterministic parameter value for analysis, are developed. The concept adopted is to select a single representative value for a specific parameter that, when used in a deterministic analysis, results in a dose estimate close to the value of the mean dose estimate that would result from a probabilistic analysis.

The following are the criteria used in developing template files for the deterministic analysis:

- For behavioral and metabolic parameters, values from DandD code (Beyeler, et al. 1999) were used. If the parameter is scenario-dependent, the value provided in the description of the scenario was used.
- For the site-specific parameters that are readily available, such as room area, room height, precipitation rate, size and depth of contamination, thickness of the cover material, and so on, the site-specific value should be used in the analysis, if available.
- If the parameter had a significant effect on peak total dose (see Section 5), reasonable effort should be made to obtain the site-specific value. If the site-specific value was not available, for a positively correlated parameter the higher percentile (e.g., 75 percent) was used, and for a negatively correlated parameter, the lower percentile (e.g., 25 percent) from the parameter distribution was used.
- For the positively correlated parameter, if the 75th percentile value from the distribution was less than the mean value from the distribution or DandD default value, then the mean or median value from the distribution or DandD default value was used.
- For the negatively correlated parameter, if the 25th percentile value from the distribution was higher than the mean value from the distribution or DandD default value, then the mean or median value from the distribution or DandD default value was used.
- If a parameter does not have significant effect on dose/risk for a given scenario, the mean, median, or most likely value from the parameter distribution was used.
- For the rest of the parameters such as translocation factors and storage times, DandD code defaults were used; if the parameter was not available in DandD code such as exposure duration, RESRAD defaults were used.

6.1 Template File for Resident Farmer Scenario

To develop radionuclide-specific template files for deterministic analysis, the parameters with high correlation are assigned more conservative values than most of the values in the distribution, as discussed previously. The external gamma shield factor is kept at the DandD default value of 0.552 because this value is higher than the 75th percentile from the distribution. Similarly, building height is kept at the most likely value from the distribution because the 25th percentile value of building room height from the distribution (3.89 m) is higher than the most likely value (3.7 m) from the distribution. Table 6-1 lists the deterministic values selected for highly correlated parameters for 12 radionuclides in the template file. Table 6-1 also lists parameters' plus or minus correlation. A separate run gives the deterministic dose from each radionuclide. Table 6-2 lists the peak total dose for each radionuclide replacing the values for parameters identified sensitive to peak total dose with the parameter values listed in Table 6-1. Table 6-2 also provides the peak total dose from the deterministic run using the DandD parameter default values in Table B-2, peak of the mean, mean of the peak, and values at the 50 percent, 75 percent, 90 percent, and 95 percentiles from probabilistic analysis using the parameter values listed in Table B-2. For all radionuclides, dose is higher than the peak of the mean and 75th percentile dose values.

Table 6-1 Dose-Sensitive Parameters, Correlation (+ or −), and Value Used in Template File for the Resident Farmer Scenario

Parameter for Radionuclide	Unit	Correlation	Table B-2 Value	Template File Value
C-14				
Thickness of contaminated zone	m	+	0.15	2.07
Area of contaminated zone	m^2	+	2400	5660
Wind speed	m/s	−	4.2	3.6
Density of contaminated zone	g/cm^3	+	1.43	1.67
C-14 evasion flux rate from soil	1/s	+	7.0E-07	9.71E-07
Thickness of evasion layer of C-14 in soil	m	+	0.3	0.4268
Co-60				
External gamma shielding factor	none	+	0.552	0.552
Plant transfer factor for Co-60	pCi/g plant per pCi/g soil	+	8.00E-02	1.5E-01
Thickness of contaminated zone	m	+	0.15	2.07
Area of contaminated zone	m^2	+	2400	5660
Cs-137				
Plant transfer factor for Cs-137	pCi/g plant per pCi/g soil	+	4.00E-02	8.00E-02
External gamma shielding factor	none	+	0.552	0.552
Thickness of contaminated zone	m	+	0.15	2.07

Note: When area of contaminated zone was changed to 5660 m^2, length parallel to aquifer flow was also changed to 75.23 m [length parallel to aquifer flow = square root (area of contaminated zone)].

Table 6-1 Dose-Sensitive Parameters, Correlation (+ or −), and Value Used in Template File for the Resident Farmer Scenario (cont.)

Parameter for Radionuclide	Unit	Correlation	Table B-2 Value	Template File Value
Cs-137 (cont.)				
Depth of roots	m	−	2.15	1.23
Meat transfer factor for Cs-137	pCi/g per pCi/d	+	2.19E-02	4.00E-02
Milk transfer factor for Cs-137	pCi/L per pCi/d	+	4.61E-03	7.40E-03
Plant transfer factor for Cs-137	pCi/g plant per pCi/g soil	+	4.00E-02	8.00E-02
External gamma shielding factor	none	+	0.552	0.552
Thickness of contaminated zone	m	+	0.15	2.07
Depth of roots	m	−	2.15	1.23
Meat transfer factor for Cs-137	pCi/g per pCi/d	+	2.19E-02	4.00E-02
Milk transfer factor for Cs-137	pCi/L per pCi/d	+	4.61E-03	7.40E-03
Livestock fodder intake for milk	kg/d	+	63.2	87.698
Livestock intake of soil	kg/d	+	0.5	0.694
Density of contaminated zone	g/cm^3	+	1.43	1.67
Area of contaminated zone	m^2	+	2400	5660
H-3				
Thickness of contaminated zone	m	+	0.15	2.07
Depth of roots	m	−	2.15	1.23
Runoff coefficient	none	+	0.31	0.63
Density of contaminated zone	g/cm^3	+	1.43	1.67
Precipitation	m/yr	−	1	0.71
K_d of H-3 in contaminated zone	cm^3/g	−	0.06	0.043
Contaminated zone total porosity	none	−	0.46	0.37

ote: When area of contaminated zone was changed to 5660 m^2, length parallel to aquifer flow was also changed to 75.23 m [length parallel to aquifer flow = square root (area of contaminated zone)].

Table 6-1 Dose-Sensitive Parameters, Correlation (+ or −), and Value Used in Template File for the Resident Farmer Scenario (cont.)

Parameter for Radionuclide	Unit	Correlation	Table B-2 Value	Template File Value
H-3 (cont.)				
Livestock water intake for milk	L/d	-	60	83.258
Contaminated zone hydraulic conductivity	m/yr	+	10	41.2
Livestock fodder intake for milk	kg/d	+	63.2	87.698
Contaminated zone b parameter	none	−	3.59	1.86
I-129				
Plant transfer factor for I-129	pCi/g plant per pCi/g soil	+	2.00E-02	3.70E-02
Thickness of contaminated zone	m	+	0.15	2.07
Milk transfer factor for I-129	pCi/L per pCi/d	+	5.41E-03	9.90E-03
Depth of roots	m	-	2.15	1.23
Meat transfer factor for I-129	pCi/g per pCi/d	+	6.67E-03	1.50E-02
K_d of I-129 in saturated zone	g/cm^3	−	7	2.4
Saturated zone hydraulic conductivity	m/yr	+	10	41.2
Saturated zone hydraulic gradient	none	+	0.02	0.019
Livestock intake of soil	kg/d	+	0.5	0.694
K_d of I-129 in unsaturated zone	g/cm^3	−	7	2.4
Np-237				
Plant transfer factor for Np-237	pCi/g plant per pCi/g soil	+	2.00E-02	3.70E-02
Thickness of contaminated zone	m	+	0.15	2.07
Depth of roots	m	-	2.15	1.23
External gamma shielding factor	none	+	0.552	0.552
Note: When area of contaminated zone was changed to 5660 m^2, length parallel to aquifer flow was also changed to 75.23 m [length parallel to aquifer flow = square root (area of contaminated zone)].				

Table 6-1 Dose-Sensitive Parameters, Correlation (+ or −), and Value Used in Template File for the Resident Farmer Scenario (cont.)

Parameter for Radionuclide	Unit	Correlation	Table B-2 Value	Template File Value
Np-237 (cont.)				
K_d of Np-237 in saturated zone	cm^3/g	-	36	11
Saturated zone effective porosity	none	-	0.355	0.289
Pu-239				
Plant transfer factor for Pu-239	pCi/g plant per pCi/g soil	+	1.00E-03	1.90E-03
Thickness of contaminated zone	m	+	0.15	2.07
Depth of roots	m	−	2.15	1.23
Meat transfer factor for Pu-239	pCi/g per pCi/d	+	1.1E-6	9.5E-6
Total porosity of unsaturated zone	none	+	0.46	0.4835
Ra-226				
Building air exchange rate	per h	−	1.52	0.84
Thickness of contaminated zone	m	+	0.15	2.07
Plant transfer factor for Ra-226	pCi/g plant per pCi/g soil	+	4.00E-02	7.5E-02
Depth of roots	m	−	2.15	1.23
Rn-222 emanation coefficient		+	0.25	0.423
Plant transfer factor for Pb	pCi/g plant per pCi/g soil	+	4.0E-03	7.5E-03
Building foundation radon diffusion coefficient	m^2/s	+	3.00E-07	3.5E-07
Building room height	m	-	3.7	3.7
External gamma shielding factor	none	+	0.552	0.552
Building foundation total porosity	none	+	0.1	0.16

Note: When area of contaminated zone was changed to 5660 m^2, length parallel to aquifer flow was also changed to 75.23 m [length parallel to aquifer flow = square root (area of contaminated zone)].

Table 6-1 Dose-Sensitive Parameters, Correlation (+ or −), and Value Used in Template File for the Resident Farmer Scenario (cont.)

Parameter for Radionuclide	Unit	Correlation	Table B-2 Value	Template File Value
Ra-226 (cont.)				
Building foundation thickness	m	-	0.15	0.14
Density of contaminated zone	g/cm^3	+	1.43	1.67
Contaminated zone total porosity		−	0.46	0.37
Ra-228				
Plant transfer factor for Ra-228	pCi/g plant per pCi/g soil	+	4.0E-02	7.5E-02
Thickness of contaminated zone	m	+	0.15	2.07
Depth of roots	m	−	2.15	1.23
External gamma shielding factor	none	+	0.552	0.552
Milk transfer factor for Ra-228	pCi/L per pCi/d	+	3.8E-4	1.1E-03
Effective porosity of unsaturated zone	none	+	0.355	0.4209
Sr-90				
Plant transfer factor for Sr-90	pCi/g plant per pCi/g soil	+	3.00E-01	5.90E-01
Thickness of contaminated zone	m	+	0.15	2.07
Depth of roots	m	−	2.15	1.23
Milk transfer factor for Sr-90	pCi/L per pCi/d	+	1.3E-03	1.8E-03
Tc-99				
Plant transfer for Tc-99	pCi/g plant per pCi/g soil	+	5	9.1
Thickness of contaminated zone	m	+	0.15	2.07
Depth of roots	m	−	2.15	1.23

Note: When area of contaminated zone was changed to 5660 m^2, length parallel to aquifer flow was also changed to 75.23 m [length parallel to aquifer flow = square root (area of contaminated zone)].

Table 6-1 Dose-Sensitive Parameters, Correlation (+ or −), and Value Used in Template File for the Resident Farmer Scenario (cont.)

Parameter for Radionuclide	Unit	Correlation	Table B-2 Value	Template File Value
Tc-99 (cont.)				
K_d of Tc-99 in contaminated zone	cm^3/g	+	0.2	0.88
Milk transfer factor for Tc-99	pCi/L per pCi/d	+	1.29E-03	1.60E-03
Runoff coefficient	none	+	0.31	0.63
U-238				
Milk transfer factor for U-238	pCi/L per pCi/d	+	1.80E-03	4.30E-03
Plant transfer factor for U-238	pCi/g plant per pCi/g soil	+	2.00E-03	3.70E-03
Thickness of contaminated zone	m	+	0.15	2.07
External gamma shielding factor	none	+	0.552	0.552
Livestock intake of soil	kg/d	+	0.5	0.694
Depth of roots	m	−	2.15	1.23
Note: When area of contaminated zone was changed to 5660 m^2, length parallel to aquifer flow was also changed to 75.23 m [length parallel to aquifer flow = square root (area of contaminated zone)].				

Table 6-2 Comparison of Deterministic Dose (mrem/yr per pCi/g) Calculated Using Data Template File with Calculated Dose Using DandD Defaults and Probabilistic Dose Results at Peak of the Mean, Mean of the Peak, and 50, 75, 90, and 95 Percentile Values for the Resident Farmer Scenario

Radionuclide	Deterministic Analysis		Probabilistic Analysis					
	Data Template File Value	DandD Default	Peak of the Mean	Mean of the Peak	50 Percent	75 Percent	90 Percent	95 Percent
C-14	1.41E+00	5.59E-02	6.13E-01	6.13E-01	5.11E-01	8.36E-01	1.21E+00	1.46E+00
Co-60	6.72E+00	5.39E+00	4.40E+00	4.40E+00	4.04E+00	5.19E+00	6.56E+00	7.49E+00
Cs-137	2.97E+00	1.40E+00	1.67E+00	1.67E+00	1.39E+00	1.88E+00	2.61E+00	3.36E+00
H-3	1.51E-01	1.38E-03	5.28E-02	5.28E-02	4.72E-02	8.02E-02	1.07E-01	1.23E-01
I-129	2.48E+01	4.42E-01	3.57E+00	3.57E+00	1.95E+00	3.92E+00	7.63E+00	1.16E+01
Np-237	2.50E+00	5.57E-01	1.37E+00	1.41E+00	9.63E-01	1.66E+00	2.79E+00	3.89E+00
Pu-239	2.47E-01	2.56E-02	1.39E-01	1.39E-01	8.73E-02	1.65E-01	2.95E-01	4.14E-01
Ra-226	6.17E+01	6.63E+00	2.04E+01	2.18E+01	1.57E+01	2.59E+01	4.23E+01	5.82E+01
Ra-228	3.07E+01	4.04E+00	1.56E+01	1.56E+01	9.94E+00	1.86E+01	3.29E+01	4.58E+01
Sr-90	1.06E+01	3.93E-01	5.70E+00	5.70E+00	2.87E+00	6.54E+00	1.35E+01	1.98E+01
Tc-99	3.33E+00	4.63E-02	1.55E+00	1.56E+00	8.41E-01	1.85E+00	3.68E+00	5.28E+00
U-238	3.31E-01	1.12E-01	2.21E-01	2.23E-01	1.50E-01	2.42E-01	4.08E-01	6.13E-01

6.2 Template File for Building Occupancy Scenario

To develop radionuclide-specific template files for deterministic analysis, the parameters with high correlation are assigned more conservative values, as discussed previously. If the source lifetime had negative correlation and the 25th percentile value from the parameter distribution (18,300 days) was higher than the most likely value from the parameter distribution (10,000 days), then the source lifetime value is kept at most likely value from the distribution.

Table 6-3 lists the deterministic values selected for highly correlated parameters for 12 radionuclides in the template file. Table 6-3 also lists parameters' plus or minus correlation. A separate run gives the peak total dose for each radionuclide replacing the values for parameters for which peak total dose was identified sensitive with the parameter values listed in Table 6-3.

Table 6-4 lists the peak total dose for each radionuclide replacing the values for parameters identified sensitive to peak total dose with the parameter values listed in Table 6-3. Table 6-4 also provides the peak total dose from the deterministic run using the DandD parameter default values in Table B-26, peak of the mean, mean of the peak, and values at the 50 percent, 75 percent, 90 percent, and 95 percentiles from probabilistic analysis using the parameter values listed in Table B-26.

Table 6-3 Dose-Sensitive Parameters, Correlation (+ or −), and Value Used in the Template File for the Building Occupancy Scenario

Parameters for Radionuclide	Unit	Correlation	Table B-26 Value	Template File Value
C-14				
Resuspension rate	1/s	-	6.80E-08	6.7E-10
Deposition velocity	m/s	+	3.90E-04	4.80E-04
Co-60				
Resuspension rate	1/s	-	6.80E-08	6.7E-10
Deposition velocity	m/s	+	3.90E-04	4.80E-04
Source lifetime of contaminated floor	days	+	10,000	52,800
Source lifetime of west contaminated wall	days	-	10,000	10,000
Source lifetime of east contaminated wall	days	-	10,000	10,000
Source lifetime of north contaminated wall	days	-	10,000	10,000
Source lifetime of south contaminated wall	days	-	10,000	10,000
Cs-137				
Resuspension rate	1/s	-	6.80E-08	6.7E-10
Deposition velocity	m/s	+	3.90E-04	4.80E-04
Source lifetime of contaminated floor	days	+	10,000	52,800
Source lifetime of contaminated roof	days	+	10,000	52,800
Note: Source 1, floor; source 2 roof; source 3 west wall; source 4 east wall; source 5 north wall; source 6 south wall.				

Table 6-3 Dose-Sensitive Parameters, Correlation (+ or −), and Value Used in the Template File for the Building Occupancy Scenario (cont.)

Parameters for Radionuclide	Unit	Correlation	Table B-26 Value	Template File Value
H-3				
Resuspension rate	1/s	-	6.80E-08	6.7E-10
Deposition velocity	m/s	+	3.90E-04	4.80E-04
Source lifetime of contaminated floor	days	-	10,000	10,000
Source lifetime of contaminated roof	days	-	10,000	10,000
Source lifetime of west contaminated wall	days	-	10,000	10,000
Source lifetime of north contaminated wall	days	-	10,000	10,000
Source lifetime of east contaminated wall	days	-	10,000	10,000
Source lifetime of south contaminated wall	days	-	10,000	10,000
I-129				
Resuspension rate	1/s	-	6.80E-08	6.7E-10
Deposition velocity	m/s	+	3.90E-04	4.80E-04
Np-237				
Source lifetime of contaminated roof	days	-	10,000	10,000
Source lifetime of contaminated floor	days	-	10,000	10,000
Resuspension rate	1/s	-	6.80E-08	6.7E-10
Deposition velocity	m/s	+	3.90E-04	4.80E-04
Source lifetime of north contaminated walls	days	-	10,000	10,000
Source lifetime of west contaminated wall	days	-	10,000	10,000
Source lifetime of east contaminated wall	days	-	10,000	10,000
Source lifetime of south contaminated wall	days	-	10,000	10,000
Note: Source 1, floor; source 2 roof; source 3 west wall; source 4 east wall; source 5 north wall; source 6 south wall.				

Table 6-3 Dose-Sensitive Parameters, Correlation (+ or −), and Value Used in the Template File for the Building Occupancy Scenario (cont.)

Parameters for Radionuclide	Unit	Correlation	Table B-26 Value	Template File Value
Pu-239				
Source lifetime of contaminated roof	days	-	10,000	10,000
Source lifetime of contaminated floor	days	-	10,000	10,000
Source lifetime of contaminated walls	days	-	10,000	10,000
Resuspension rate	1/s	-	6.80E-08	6.7E-10
Deposition velocity	m/s	+	3.90E-04	4.80E-04
Source lifetime of north contaminated walls	days	-	10,000	10,000
Source lifetime of west contaminated wall	days	-	10,000	10,000
Source lifetime of east contaminated wall	days	-	10,000	10,000
Source lifetime of south contaminated wall	days	-	10,000	10,000
Ra-226				
Resuspension rate	1/s	-	6.80E-08	6.7E-10
Source lifetime of contaminated roof	days	-	10,000	10,000
Deposition velocity	m/s	-	3.90E-04	1.52E-05
Source lifetime of contaminated floor	days	-	10,000	10,000
Ra-228				
Deposition velocity	m/s	-	3.90E-04	1.52E-05
Source lifetime of contaminated roof	days	-	10,000	10,000
Source lifetime of contaminated floor	days	-	10,000	10,000
Sr-90				
Resuspension rate	1/s	-	6.80E-08	6.7E-10
Deposition velocity	m/s	+	3.90E-04	4.80E-04

Note: Source 1, floor; source 2 roof; source 3 west wall; source 4 east wall; source 5 north wall; source 6 south wall.

Table 6-3 Dose-Sensitive Parameters, Correlation (+ or −), and Value Used in the Template File for the Building Occupancy Scenario (cont.)

Parameters for Radionuclide	Unit	Correlation	Table B-26 Value	Template File Value
Sr-90 (cont.)				
Resuspension rate	1/s	-	6.80E-08	6.7E-10
Deposition velocity	m/s	+	3.90E-04	4.80E-04
Source lifetime of contaminated roof	days	-	10,000	10,000
Source lifetime of contaminated floor	days	-	10,000	10,000
Source lifetime of west contaminated wall	days	-	10,000	10,000
Source lifetime of east contaminated wall	days	-	10,000	10,000
Source lifetime of north contaminated wall	days	-	10,000	10,000
Source lifetime of south contaminated wall	days	-	10,000	10,000
Tc-99				
Resuspension rate	1/s	-	6.80E-08	6.7E-10
Deposition velocity	m/s	+	3.90E-04	4.80E-04
Source lifetime of contaminated roof	days	-	10,000	10,000
Source lifetime of contaminated floor	days	-	10,000	10,000
Source lifetime of north contaminated wall	days	-	10,000	10,000
Source lifetime of east contaminated wall	days	-	10,000	10,000
Source lifetime of west contaminated wall	days	-	10,000	10,000
Source lifetime of south contaminated wall	days	-	10,000	10,000

Note: Source 1, floor; source 2 roof; source 3 west wall; source 4 east wall; source 5 north wall; source 6 south wall.

Table 6-3 Dose-Sensitive Parameters, Correlation (+ or −), and Value Used in the Template File for the Building Occupancy Scenario (cont.)

Parameters for Radionuclide	Unit	Correlation	Table B-26 Value	Template File Value
U-238				
Source lifetime of contaminated floor	days	-	10,000	10,000
Source lifetime of contaminated roof	days	-	10,000	10,000
Resuspension rate	1/s	-	6.80E-08	6.7E-10
Source lifetime of east contaminated wall	days	-	10,000	10,000
Source lifetime of north contaminated wall	days	-	10,000	10,000
Source lifetime of south contaminated wall	days	-	10,000	10,000
Source lifetime of west contaminated wall	days	-	10,000	10,000
Deposition velocity	m/s	+	3.90E-04	4.80E-04
Note: Source 1, floor; source 2 roof; source 3 west wall; source 4 east wall; source 5 north wall; source 6 south wall.				

Table 6-4 Comparison of Deterministic Dose (mrem/yr per pCi/m^2) Calculated Using Data Template File with Calculated Dose Using DandD Defaults and Probabilistic Dose Results at Peak of the Mean of the Peak, and 50, 75, 90, and 95 Percentile Values for the Building Occupancy Scenario

	Deterministic Analysis		Probabilistic Analysis					
Radionuclide	Data Template File Value	DandD Default	Peak of the Mean	Mean of the Peak	50 percent	75 percent	90 percent	95 percent
C-14	9.84E-08	5.43E-08	8.07E-08	5.41E-08	5.72E-08	9.32E-08	1.73E-07	9.84E-08
Co-60	4.18E-05	4.16E-05	4.16E-05	4.16E-05	4.16E-05	4.17E-05	4.17E-05	4.18E-05
Cs-137	1.17E-05	1.14E-05	1.15E-05	1.14E-05	1.15E-05	1.17E-05	1.19E-05	1.17E-05
H-3	2.45E-08	1.70E-08	1.73E-08	1.65E-08	1.71E-08	1.97E-08	2.24E-08	2.45E-08
I-129	1.37E-05	7.77E-06	1.18E-05	7.78E-06	8.19E-06	1.31E-05	2.45E-05	1.37E-05
Np-237	4.14E-04	3.19E-04	2.76E-04	2.12E-04	2.54E-04	3.49E-04	4.88E-04	4.14E-04
Pu-239	3.26E-04	2.51E-04	2.15E-04	1.65E-04	1.99E-04	2.74E-04	3.80E-04	3.26E-04
Ra-226	8.25E-05	8.02E-05	9.24E-05	7.98E-05	8.15E-05	1.01E-04	1.48E-04	8.25E-05
Ra-228	1.71E-04	1.50E-04	1.46E-04	1.54E-04	1.59E-04	1.62E-05	1.66E-04	1.71E-04
Sr-90	5.59E-06	4.43E-06	4.34E-06	4.20E-06	4.33E-06	4.71E-06	5.19E-06	5.59E-06
Tc-99	7.25E-08	4.15E-08	6.12E-08	4.02E-08	4.24E-08	6.79E-08	1.28E-07	7.25E-08
U-238	5.73E-05	5.16E-05	3.19E-05	2.71E-05	3.45E-05	4.49E-05	5.72E-05	5.73E-05

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APPENDIX A PARAMETERS AND PARAMETER TYPES IN RESRAD-ONSITE, RESRAD-OFFSITE, AND RESRAD-BUILD CODES

A.1 INTRODUCTION

This appendix presents tables listing characteristics of the parameters used in RESRAD-ONSITE Version 7.2, RESRAD-OFFSITE Version 4.0, and RESRAD-BUILD Version 3.5 codes. These tables include parameter name, default value, code-accepted range of values for the parameter, parameter type, references for more information, and the general description of the parameter.

The parameters used in the RESRAD family of codes are classified into three types: physical, behavioral, or metabolic, as described in this Appendix. Some parameters may belong to more than one of these types (e.g., the mass loading factor). Additionally, if a parameter does not fit either the physical or metabolic definition, it is classified as a behavioral parameter. Many parameters used in the RESRAD-OFFSITE code are the same as those used in the RESRAD-ONSITE code (Yu et al. 2001); therefore, the same parameters are assigned the same parameter types (NRC 2000).

Physical Parameter: any parameter whose value would not change if a different group of receptors were considered. Physical parameters are determined by the source, its location, and the geological characteristics of the site (i.e., these parameters are source- and site-specific).

Behavioral Parameter: any parameter whose value depends on the receptor's behavior and the scenario definition. For the same group of receptors, a parameter value could change if the scenario changes (e.g., parameters for recreational use could be different from those for residential use).

Metabolic Parameter: a parameter that represents the metabolic characteristics of the potential receptor and is independent of the scenario. The parameter values may be different in different population age groups. According to the recommendations of the International Commission on Radiological Protection, Report 43 (ICRP 1985), parameters that represent metabolic characteristics are defined by average values for the general population. These values are not expected to be modified for a site-specific analysis because the parameter values would not depend on site conditions.

Table A-1[1] lists user parameters in the RESRAD-ONSITE code. Parameters in this table are arranged according to the input window in which they appear. The number of parameters a user can change depends on the pathways and radionuclide selected. In RESRAD-ONSITE and RESRAD-OFFSITE codes, pathways can be turned on and off. Parameters pertaining to suppressed pathways are disabled in the data entry screens because they will not be used in the calculations. Radon parameters can only be changed if a radon precursor is selected in the radionuclide list and the radon pathway is turned on. Similarly, carbon-14 (C-14) and tritium (H-3) parameters can only be changed if C-14 and H-3 respectively are selected in the radionuclide list. Some parameters are nuclide or element specific. Separate tables for element-specific data are provided (Table A-2 through Table A-4). Table A-1 also identifies the parameter types: physical (P), metabolic (M), and behavioral (B). For some parameters, more than one type is listed; the first one listed is the primary type and the next one is secondary. For example, the inhalation rate is identified as M, B, which indicates that it depends primarily on the

[1] To maintain the continuity of the text, the tables have been placed at the end of the section.

metabolic characteristics of the potential receptor, but it also depends on the receptor behavior or exposure scenario. The default values are the current defaults in the code.

In RESRAD-ONSITE and RESRAD-OFFSITE codes, the user has an option to select the ICRP 107 (ICRP 2008)-based or ICRP 38 (ICRP 1983) -based radionuclide transformation database. If the ICRP 107 radionuclide transformation database is selected, only the ICRP 60 (ICRP 1991) -based external, inhalation, and ingestion dose coefficients are available. If the ICRP 38 radionuclide transformation database is selected, the ICRP 26 (ICRP 1977) -based external, inhalation, and ingestion dose coefficients are also available. RESRAD-BUILD only has the ICRP 38-based radionuclide transformation database.

If the ICRP 107 radionuclide transformation database is selected, the DCFPAK 3.02 internal dose coefficients library for any listed age groups or DOE STD-1196-2011 (Reference Person) can be selected for the analysis. The Reference Person is defined as a hypothetical aggregation of human (male and female) physical and physiological characteristics arrived at by international consensus for standardizing radiation dose calculations. The Reference Person dose coefficients are derived using age-specific dose coefficients coupled with information on the age and gender structure of the U.S. population in 2000 census data and age- and gender-specific intakes (DOE 2011). If the ICRP 38 radionuclide transformation database is selected, the FGR 11 (Eckerman et al., 1988) dose coefficient library or age-dependent ICRP 72 (ICRP 1996) libraries can be selected for the analysis. FGR 11 internal dose coefficients are based on ICRP 26 methodology, and ICRP 72 internal dose coefficients are based on ICRP 60 methodology.

If site-specific dose coefficients are available, the user can create their own dose coefficient libraries by changing the values in the base library. This is done by using the Dose Conversion Factor Editor, which is a standalone utility program common to the RESRAD family of codes. The base external dose coefficient library is automatically selected based on the internal dose library selection. For example, if the FGR 11 internal dose library is chosen, the external dose library used is FGR 12 (Eckerman et al., 1993).

If the ICRP 107 radionuclide transformation database is selected, DCFPAK 3.02 Morbidity or Mortality risk factor libraries can be selected for the analysis. If the ICRP 38 radionuclide transformation database is selected, the standard FGR 13 morbidity or mortality (Eckerman et al., 1999) or HEAST 2001 morbidity (EPA, 2001) slope factor libraries can be selected for the analysis. Users also can create their own risk factor libraries and select them for the analysis.

Table A-5 includes parameter name, default value, code-accepted Table A-2 provides default values and distribution for the distribution coefficient parameter for different elements used in RESRAD-ONSITE and RESRAD-OFFSITE code. Table A-3 provides element-specific transfer factors for plants, meat, and milk. Table A-4 provides element-specific bioaccumulation factors for fish and for Crustacea and mollusks. The values are in the RESRAD DCF Editor. Users also can create their own library by changing the default values in the DCF Editor for use in the analysis.

range of values for the parameter, parameter type, and the general description of the parameter. Additional information about the parameters can be obtained from the RESRAD-OFFSITE "help" function in the code. Table A-2 has default distribution coefficients which are element specific, but the code can accept different values for different isotopes of an element when that information exists for a particular site. Table A-3 lists element-specific transfer factors for plants, meat, and milk. Although only one "default" value is available for the plant transfer factor in the database, the user can input four different root uptake transfer factors for the four different types of plants (leafy vegetables; grains, fruit, and nonleafy vegetables; pasture and silage for livestock; and grains for livestock) grown in different areas in RESRAD-OFFSITE.

Table A-6 lists the parameters used in the RESRAD-BUILD V3.5, the pathways in which they are used, and their description. Additional information about these parameters can be obtained from Yu et al. (2003). Dose conversion factors for direct external exposure, inhalation, and ingestion pathways used in the RESRAD-BUILD code are the same as those used in RESRAD-ONSITE. The ICRP107-based radionuclide transformation database is not included in RESRAD-BUILD code. Table A-6 also lists the RESRAD-BUILD parameter types identified. As was the case for RESRAD-ONSITE (Table A-1) and RESRAD-OFFSITE (Table A-5), more than one attribute may be identified for some parameters. For example, shielding thickness is identified as P, B, meaning that it depends primarily on the source or site-specific conditions; but it also can be modified by receptor behavior as a secondary attribute.

Table A-1 Parameters and Their Default Values Used in Version 7.2 of RESRAD-ONSITE

Parameter Name	Unit	Default Value	Code-Accepted Values[a]	Type[b]	References	Description
Title						
Title	–	RESRAD default parameters	80 alphabetic or numeric characters	NA	Kamboj et al., 2018	The Title is used to identify the run and can be up to 80 alphabetic or numeric characters long.
Radionuclide transformations based on		ICRP 107	ICRP 107 or ICRP 38	NA	Kamboj et al., 2018	The code has radionuclide transformation based on ICRP 107 as well as on ICRP 38.
Internal dose library	–	DCFPAK 3.02 (Adult)	DOE STD-1196-2011 (Reference Person), DCFPAK 3.02 - Adult DCFPAK 3.02 - Infant DCFPAK 3.02 - Age 1 DCFPAK 3.02 - Age 5 DCFPAK 3.02 - Age 10 DCFPAK 3.02 - Age 15 ICRP 72 – Adult ICRP 72 – Infant ICRP 72 - Age 1; ICRP 72 - Age 5; ICRP 72 - Age 10; ICRP 72 - Age 15; FGR 11, user specified	NA	Kamboj et al., 2018	The DOE-STD-1196-2011 (Reference Person) internal dose library is based on ICRP60 methodology and radionuclide transformation data from ICRP-107. For radionuclide transformation based on ICRP 107, the dose coefficients are from DCFPAK 3.02 and are from ICRP 60 methodology. For radionuclide transformation based on ICRP 38, the dose coefficients are available from ICRP 26 methodology in FGR 11) and from ICRP 60 methodology in ICRP 72. Usually, values for more than one inhalation class are listed per radionuclide. The three classes D, W, and Y in FGR 11 correspond to retention half-times of less than 10 days, 10 to 100 days, and greater than 100 days; respectively. The most conservative dose conversion factor is chosen as the default. The values can be changed if chemical forms are known or more appropriate data are available.
External dose library	–	DCFPAK 3.02	DCFPAK 3.02 FGR 12 FGR 13	NA	Kamboj et al., 2018	This library is selected based on the selection for internal exposure dose library.

[a] Code-accepted values are not provided for element- or nuclide-specific parameters.
[b] P = physical, B = behavioral, M = metabolic; when more than one type is listed, the first is primary and the next is secondary.
[c] "–" indicates that the parameter is dimensionless.
[d] Groundwater concentration can be input only if time since placement of material is greater than 0.
[e] This parameter should be used only if radionuclide leach rates are known.
[f] NA = not applicable.

Table A-1 Parameters and Their Default Values Used in Version 7.2 of RESRAD-ONSITE (cont.)

Parameter Name	Unit	Default Value	Code-Accepted Values[a]	Type[b]	References	Description
Title (cont.)						
Risk factors	–	DCFPAK 3.02 Morbidity	DCFPAK 3.02 morbidity DCFPAK 3.02 mortality FGR 3 morbidity FGR 13 mortality or HEAST 2001 morbidity	NA	Kamboj et al., 2018	This is the name of the slope factor library containing all slope factors for the RESRAD-ONSITE V7.2 pathways.
Cutoff half-life	–	180 days	≥ 10 minutes	NA	Kamboj et al., 2018	This is the cutoff half-life that is used to separate the "principal nuclides" from the "associated nuclides."
Number of points for graphics	–	32	32, 64, 128, 256, 512, 1024	NA	Kamboj et al., 2018	This parameter specifies the number of graphic points. It affects the smoothness of the output graphic curves.
Spacing of graphic parameters	–	Log	Log, Linear	NA	Kamboj et al., 2018	Linear or Log is to specify the type of spacing in years between the generated graphic time points.
Maximum time integration points for dose	–	17	1, 5, 9, 17	NA	Kamboj et al., 2018	Number of time integration points used in calculating average yearly dose.
Maximum time integration points for risk	–	257	1, 5, 9, 17, 33, 65, 129, 513	NA	Kamboj et al., 2018	Number of time integration points used in calculating risk over the exposure duration.
Source						
Radionuclide unit of activity	–	pCi	Traditional or SI	NA	Yu et al., 2001	The code accepts values in traditional units or SI units.
Radionuclide unit of dose	–	mrem	Traditional or SI	NA	Yu et al., 2001	The code accepts values in traditional units or SI units.
Basic radiation dose limit	–	25	Site specific	NA	Yu et al., 2015	The annual radiation dose limit in mrem/yr used to derive all site-specific guidelines.
Radionuclide concentration	–	100	Site specific	P	Yu et al., 2015	Average radionuclide concentration in the contaminated zone. The contaminated zone is treated as a uniformly contaminated volume with the same radionuclide concentration.

[a] Code-accepted values are not provided for element- or nuclide-specific parameters.
[b] P = physical, B = behavioral, M = metabolic; when more than one type is listed, the first is primary and the next is secondary.
[c] "–" indicates that the parameter is dimensionless.
[d] Groundwater concentration can be input only if time since placement of material is greater than 0.
[e] This parameter should be used only if radionuclide leach rates are known.
[f] NA = not applicable.

Table A-1 Parameters and Their Default Values Used in Version 7.2 of RESRAD-ONSITE (cont.)

Parameter Name	Unit	Default Value	Code-Accepted Values[a]	Type[b]	References	Description
Transport Factors						
Distribution coefficients (contaminated zone, unsaturated zones, and saturated zones)	cm^3/g	Nuclide specific		P	Yu et al., 2015	Site-specific values should be used everywhere for each radionuclide. Default values are provided by the code for most radionuclides. However, these values should be used with care as distribution coefficients can vary over many orders of magnitude.
Number of unsaturated zones	–[c]	1	0–5 (integer value)	P	Yu et al., 2001	An unsaturated zone is defined as a horizontal uncontaminated layer located between the contaminated zone and the aquifer. The code allows for a maximum of five unsaturated zones.
Time since placement of material	yr	0	0–100	P	Yu et al., 2015	The duration between the placement of radioactive material on-site and the performance of a radiological survey. A non-zero value for this parameter is necessary to activate the groundwater concentration input box. The non-zero value of this parameter is used along with groundwater concentration to calculate the water/soil concentration ratio and effective distribution coefficient. If a distribution coefficient is calculated using this or any of other options that follow, the code sets the distribution coefficient in all the zones (contaminated, unsaturated, saturated) to this value.
Groundwater concentration	pCi/L	0[d]	0–1E+34	P	Yu et al., 2015	The measured groundwater concentration of principal radionuclides. The groundwater concentration should be measured at the same time the soil concentrations are measured. Groundwater concentration can be input only if time since placement of material is greater than zero.

[a] Code-accepted values are not provided for element- or nuclide-specific parameters.
[b] P = physical, B = behavioral, M = metabolic; when more than one type is listed, the first is primary and the next is secondary.
[c] "–" indicates that the parameter is dimensionless.
[d] Groundwater concentration can be input only if time since placement of material is greater than 0.
[e] This parameter should be used only if radionuclide leach rates are known.
[f] NA = not applicable.

Table A-1 Parameters and Their Default Values Used in Version 7.2 of RESRAD-ONSITE (cont.)

Parameter Name	Unit	Default Value	Code-Accepted Values[a]	Type[b]	References	Description
Transport Factors (cont.)						
Leach rate[e]	1/yr	(Nuclide specific)	0–1E+34	P	Yu et al., 2015	The fraction of the available radionuclide leached from the contaminated zone per unit of time. Radionuclide leach rates should be used if known. The non-zero leach rate is used to calculate the leaching of the radionuclide from the contaminated zone and to derive the water/soil concentration ratio and distribution coefficient. If the derived distribution coefficient is greater than zero, the input distribution coefficient would be replaced by these values.
Solubility limit	mol/L	(Nuclide specific)	0–1E+34	P	Yu et al., 2001	The solubility limit provides an additional option for calculating the distribution coefficient in the code. The solubility limit serves as an upper boundary on the amount of a radionuclide released from the soil particles.
Use plant/soil ratio	–	Unchecked	Check box	NA[f]	Yu et al., 2001	The code allows distribution coefficients to be calculated from the plant root uptake factors (plant/soil concentration ratio). This option becomes active if the plant/soil ratio box is checked.
Calculation Parameters						
Times for calculations	yr	1, 3, 10, 30, 100, 300, 1000	0–1E+5	P	Yu et al., 2001	The times in years following the radiological survey for which tabular values for single-radionuclide soil guidelines and mixture sums will be obtained. The code calculates yearly dose at time zero—the time of the survey— and up to nine user-specified times.
Contaminated Zone Parameters						
Area of contaminated zone	m^2	10,000	1E-4–1E+15	P	Yu et al., 2015	Total area of the site that is homogeneously contaminated.

[a] Code-accepted values are not provided for element- or nuclide-specific parameters.
[b] P = physical, B = behavioral, M = metabolic; when more than one type is listed, the first is primary and the next is secondary.
[c] "–" indicates that the parameter is dimensionless.
[d] Groundwater concentration can be input only if time since placement of material is greater than 0.
[e] This parameter should be used only if radionuclide leach rates are known.
[f] NA = not applicable.

Table A-1 Parameters and Their Default Values Used in Version 7.2 of RESRAD-ONSITE (cont.)

Parameter Name	Unit	Default Value	Code-Accepted Values[a]	Type[b]	References	Description
Contaminated Zone Parameters (cont.)						
Thickness of contaminated zone	m	2	1E-5–1E+3	P	Yu et al., 2015	The distance between the uppermost and lowermost soil samples that have radionuclide concentrations clearly above background.
Length parallel to aquifer flow	m	100	1E-4–1E+6	P	Yu et al., 2015	The distance between two parallel lines perpendicular to the direction of aquifer flow, one at the upgradient edge of the contaminated zone and the other at the downgradient edge. Only used for the nondispersion water transport model.
Does the initial contamination penetrate the water table	–	Unchecked	Check box	NA	Kamboj et al., 2018	The code allows to model submerged source.
Contaminated fraction below water table	–	0	0–1	NA	Kamboj et al., 2018	Fraction of the contamination that is below the water table.
Cover and Contaminated Zone Hydrological Data						
Cover depth	m	0	0–100	P	Yu et al., 2015	Distance from the ground surface to the contaminated zone.
Density of cover material	g/cm^3	1.5	1E-3–22.5	P	Yu et al., 2015	Bulk density of the cover material.
Cover erosion rate	m/yr	0.001	0–5	P, B	Yu et al., 2015	The average volume of cover material that is removed per unit of ground surface area and per unit of time. Erosion rates can be estimated by means of the universal soil loss equation.
Density of contaminated zone	g/cm^3	1.5	1E-3–22.5	P	Yu et al., 2015	Bulk density of the contaminated zone.
Contaminated zone total porosity	–	0.4	1E-5–1	P	Yu et al., 2015	Ratio of the pore volume to the total volume of the contaminated zone.

[a] Code-accepted values are not provided for element- or nuclide-specific parameters.
[b] P = physical, B = behavioral, M = metabolic; when more than one type is listed, the first is primary and the next is secondary.
[c] "–" indicates that the parameter is dimensionless.
[d] Groundwater concentration can be input only if time since placement of material is greater than 0.
[e] This parameter should be used only if radionuclide leach rates are known.
[f] NA = not applicable.

Table A-1 Parameters and Their Default Values Used in Version 7.2 of RESRAD-ONSITE (cont.)

Parameter Name	Unit	Default Value	Code-Accepted Values[a]	Type[b]	References	Description
Cover and Contaminated Zone Hydrological Data (cont.)						
Contaminated zone field capacity	–	0.2	1E-34–1	P	Yu et al., 2015	Volumetric moisture content of soil at which (free) gravity drainage ceases. This is the amount of moisture that will be retained in a column of soil against the force of gravity. The field capacity is one of several hydrogeological parameters used to calculate water transport through the unsaturated part of the soil. The user can use this input to specify a minimum moisture content for each partially saturated region. It is also called specific retention, irreducible water content, or residual water content.
Contaminated zone erosion rate	m/yr	0.001	0–5	P, B	Yu et al., 2015	The average volume of source material that is removed per unit of ground surface area and per unit of time.
Contaminated zone hydraulic conductivity	m/yr	10	1E-3–1E+10	P	Yu et al., 2015	The measure of the soil's ability to transmit water when submitted to a hydraulic gradient. The hydraulic conductivity depends on the soil grain size, the structure of the soil matrix, the type of soil fluid, and the relative amount of soil fluid (saturation) present in the soil matrix.
Contaminated zone b parameter	–	5.3	0–15	P	Yu et al., 2015	An empirical and dimensionless parameter that is used to evaluate the saturation ratio (or the volumetric water saturation) of the soil according to a soil characteristic function called the conductivity function.
Humidity in air	g/m^3	8	0–1,000	P	Yu et al., 2001	Average absolute humidity in air. It is used in the tritium model to calculate tritium concentration in air.

[a] Code-accepted values are not provided for element- or nuclide-specific parameters.
[b] P = physical, B = behavioral, M = metabolic; when more than one type is listed, the first is primary and the next is secondary.
[c] "–" indicates that the parameter is dimensionless.
[d] Groundwater concentration can be input only if time since placement of material is greater than 0.
[e] This parameter should be used only if radionuclide leach rates are known.
[f] NA = not applicable.

Table A-1 Parameters and Their Default Values Used in Version 7.2 of RESRAD-ONSITE (cont.)

Parameter Name	Unit	Default Value	Code-Accepted Values[a]	Type[b]	References	Description
Cover and Contaminated Zone Hydrological Data (cont.)						
Evapotranspiration coefficient	–	0.5	0–0.999	P	Yu et al., 2015	The ratio of the total volume of water leaving the ground via evapotranspiration to the total volume of water available within the root zone of the soil during a fixed period of time.
Wind speed	m/s	2	1E-4–20	P	Yu et al., 2015	The overall average of the wind speed, measured near the ground.
Precipitation	m/yr	1	0–10	P	Yu et al., 2015	The average volume of water in the form of rain, snow, hail, or sleet that falls per unit of area per unit of time at the site.
Irrigation	m/yr	0.2	0–10	B	Yu et al., 2015	The average volume of water that is added to the soil at the site, per unit of surface area and per unit of time. Irrigation is the practice of supplying water artificially to the soil in order to permit agricultural use of the land in an arid region or to compensate for occasional droughts in semidry or semihumid regions. It is the average annual irrigation rate. The code has two irrigation modes: overhead and ditch irrigation.
Irrigation mode	–	Overhead	Overhead/ditch	B	Yu et al., 2001	Method of irrigation; overhead or ditch.
Runoff coefficient	–	0.2	0–1	P	Yu et al., 2015	This is the fraction of precipitation that does not penetrate the top soil, but leaves the area of concern as surface runoff.
Watershed area for nearby stream or pond	m^2	1,000,000	1E-4–1E+34	P	Yu et al., 2015	The site-specific area that drains into the nearby pond.
Accuracy for water soil computation	–	0.001	0–0.1	NA	Yu et al., 2001	The fractional accuracy desired (convergence criterion) in the Romberg integration used to obtain water/soil concentration ratios.
Saturated Zone Hydrological Data						
Density of saturated zone	g/cm^3	1.5	1E-3–22.5	P	Yu et al., 2015	See "Density of contaminated zone" (above).

[a] Code-accepted values are not provided for element- or nuclide-specific parameters.
[b] P = physical, B = behavioral, M = metabolic; when more than one type is listed, the first is primary and the next is secondary.
[c] "–" indicates that the parameter is dimensionless.
[d] Groundwater concentration can be input only if time since placement of material is greater than 0.
[e] This parameter should be used only if radionuclide leach rates are known.
[f] NA = not applicable.

Table A-1 Parameters and Their Default Values Used in Version 7.2 of RESRAD-ONSITE (cont.)

Parameter Name	Unit	Default Value	Code-Accepted Values[a]	Type[b]	References	Description
Saturated Zone Hydrological Data (cont.)						
Saturated zone total porosity	–	0.4	1E-5–1	P	Yu et al., 2015	See "Contaminated zone total porosity" (above).
Saturated zone effective porosity	–	0.2	1E-34–1	P	Yu et al., 2015	The effective porosity is the ratio of the pore volume where water can flow to the total volume. It is used along with other hydrological parameters to calculate the water transport breakthrough times.
Saturated zone field capacity	–	0.2	1E-34–1	P	Yu et al., 2015	See "Contaminated zone field capacity" (above). (The field capacity and b parameter of the saturated zone are used only if the water table drop rate is positive.)
Saturated zone hydraulic conductivity	m/yr	100	1E-3–1E+10	P	Yu et al., 2015	See "Contaminated zone hydraulic conductivity" (above).
Saturated zone hydraulic gradient	–	0.02	1E-10–10	P	Yu et al., 2015	The change in hydraulic head per unit of distance in the groundwater flow direction. In an unconfined (water table) aquifer, the horizontal hydraulic gradient of groundwater flow is approximately the slope of the water table. In a confined aquifer, it represents the difference in potentiometric surfaces over a unit distance.
Saturated zone b parameter	–	5.3	1E-34–15	P	Yu et al., 2015	See "Contaminated zone b parameter" (above).
Water table drop rate	m/yr	0.001	0–5	P	Yu et al., 2015	The rate at which the depth of the water table is lowered. If the water table drop rate is greater than zero, the unsaturated zone thickness will be created or increased. The code does not allow for a negative water table drop rate.
Well pump intake depth (below water table)	m	10	1E-5–1,000	P	Yu et al., 2015	The screened depth of a well within the aquifer (the saturated zone).

[a] Code-accepted values are not provided for element- or nuclide-specific parameters.
[b] P = physical, B = behavioral, M = metabolic; when more than one type is listed, the first is primary and the next is secondary.
[c] "–" indicates that the parameter is dimensionless.
[d] Groundwater concentration can be input only if time since placement of material is greater than 0.
[e] This parameter should be used only if radionuclide leach rates are known.
[f] NA = not applicable.

Table A-1 Parameters and Their Default Values Used in Version 7.2 of RESRAD-ONSITE (cont.)

Parameter Name	Unit	Default Value	Code-Accepted Values[a]	Type[b]	References	Description
Saturated Zone Hydrological Data (cont.)						
Model for water transport parameters: nondispersion (ND) or mass-balance (MB)	–	ND	ND/MB	P	Yu et al., 2001	Two models are used in the code for calculating the water/soil concentration ratio for the groundwater pathway: a mass-balance (MB) model and a nondispersion (ND) model. The MB model assumes that a well is located at the center of the contaminated zone, and the ND model assumes that the well is located at the downgradient edge of the contaminated zone. In the MB model, it is assumed that all of the radionuclides released from the contaminated zone are withdrawn through the well. In the ND model, it is assumed that the saturated zone is a single homogenous stratum, and the water withdrawn introduces only a minor perturbation in the water flow.
Well pumping rate	m^3/yr	250	0–1E+10	B, P	Yu et al., 2001	The volume of water removed from the groundwater aquifer annually for all domestic purposes.
Uncontaminated Unsaturated Zone Parameters						
Unsaturated zone thickness	m	4	0–10,000	P	Yu et al., 2015	The thickness of the uncontaminated unsaturated zone that lies below the contaminated zone and above the groundwater table. The code has provisions for up to five different horizontal strata within this zone. Each stratum is characterized by six radionuclide independent parameters: thickness, density, total porosity, effective porosity, b parameter, and hydraulic conductivity.

[a] Code-accepted values are not provided for element- or nuclide-specific parameters.
[b] P = physical, B = behavioral, M = metabolic; when more than one type is listed, the first is primary and the next is secondary.
[c] "–" indicates that the parameter is dimensionless.
[d] Groundwater concentration can be input only if time since placement of material is greater than 0.
[e] This parameter should be used only if radionuclide leach rates are known.
[f] NA = not applicable.

Table A-1 Parameters and Their Default Values Used in Version 7.2 of RESRAD-ONSITE (cont.)

Parameter Name	Unit	Default Value	Code-Accepted Values[a]	Type[b]	References	Description
Uncontaminated Unsaturated Zone Parameters (cont.)						
Unsaturated zone density	g/cm^3	1.5	1E-3–22.5	P	Yu et al., 2015	Bulk density of the unsaturated zone soil.
Unsaturated zone total porosity	–	0.4	1E-5–1	P	Yu et al., 2015;	See “Contaminated zone total porosity” (above).
Unsaturated zone effective porosity	–	0.2	1E-34–1	P	Yu et al., 2015	See “Saturated zone effective porosity” (above).
Unsaturated zone field capacity	–	0.2	1E-34–1	P	Yu et al., 2001	See “Contaminated zone field capacity” (above).
Unsaturated zone, soil-specific b parameter	–	5.3	0–15	P	Yu et al., 2015	See “Contaminated zone b parameter” (above).
Unsaturated zone hydraulic conductivity	m/yr	10	1E-3–1E+10	P	Yu et al., 2015	See “Contaminated zone hydraulic conductivity” (above).
Occupancy, Inhalation, and External Gamma Data						
Inhalation rate	m^3/yr	8,400	0–20,000	M, B	Yu et al., 2015	The annual air intake in m^3/yr. The default value of 8,400 m^3/yr is recommended by the International Commission on Radiological Protection (1975).
Mass loading for inhalation	g/m^3	1.00E-04	0–2	P, B	Yu et al., 2015	This is the average mass loading of respirable airborne contaminated soil particles. The code uses this parameter along with area factor for inhalation pathway dose estimation.
Exposure duration	yr	30	1–1,000	B	Yu et al., 2001	The exposure duration is the span of time, in years, during which an individual is expected to spend time on the site. This value is used in calculating lifetime cancer risk from exposure to radionuclide contamination.
Indoor dust filtration factor	–	0.4	0–1	P, B	Yu et al., 2015	Describes the effect of the building structure on the level of contaminated dust existing indoors. This is the fraction of the outdoor contaminated dust that will be available indoors.

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[b] P = physical, B = behavioral, M = metabolic; when more than one type is listed, the first is primary and the next is secondary.
[c] “–” indicates that the parameter is dimensionless.
[d] Groundwater concentration can be input only if time since placement of material is greater than 0.
[e] This parameter should be used only if radionuclide leach rates are known.
[f] NA = not applicable.

Table A-1 Parameters and Their Default Values Used in Version 7.2 of RESRAD-ONSITE (cont.)

Parameter Name	Unit	Default Value	Code-Accepted Values[a]	Type[b]	References	Description
Occupancy, Inhalation, and External Gamma Data (cont.)						
External gamma shielding factor	–	0.7	0–1	P	Yu et al., 2015	Describes the effect of building structure on the level of gamma radiation existing indoors. It is the fraction of the outdoor gamma radiation that will be available indoors. The shielding factor value is used in calculating the occupancy factor.
Indoor time fraction	–	0.5	0–1	B	Yu et al., 2015	The average fraction of time during which an individual stays inside the house.
Outdoor time fraction	–	0.25	0–1	B	Yu et al., 2015	The average fraction of time during which an individual stays outdoors on the site.
Shape of the contaminated zone (shape factor flag)	–	Circular	Circular/non-circular	P	Yu et al., 2015	The code has the capability to handle any shape of contaminated zone. If the shape factor flag has been set, the 12 annular area fields comprising shape factor data are calculated. The shape factor data are calculated by RESRAD by drawing 2 to 12 concentric circles emanating from the receptor location inside (or possibly outside) the contaminated area. The outermost circle circumscribes the entire contaminated zone. For each annular ring, the outer radius and fraction of the ring within the contaminated zone are calculated.
Ingestion Pathway, Dietary Data						
Fruit, vegetable, and grain consumption	kg/yr	160	0–1,000	M, B	Yu et al., 2015	The dietary factor for fruit, vegetable, and grain consumption by humans. The default is based on national averages.

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[b] P = physical, B = behavioral, M = metabolic; when more than one type is listed, the first is primary and the next is secondary.
[c] "–" indicates that the parameter is dimensionless.
[d] Groundwater concentration can be input only if time since placement of material is greater than 0.
[e] This parameter should be used only if radionuclide leach rates are known.
[f] NA = not applicable.

Table A-1 Parameters and Their Default Values Used in Version 7.2 of RESRAD-ONSITE (cont.)

Parameter Name	Unit	Default Value	Code-Accepted Values[a]	Type[b]	References	Description
Ingestion Pathway, Dietary Data (cont.)						
Fruit, vegetable, and grain consumption	kg/yr	160	0–1,000	M, B	Yu et al., 2015	The dietary factor for fruit, vegetable, and grain consumption by humans. The default is based on national averages.
Leafy vegetable consumption	kg/yr	14	0–100	M, B	Yu et al., 2015	The dietary factor for leafy vegetable consumption by humans. The default is based on national averages.
Milk consumption	L/yr	92	0–1,000	M, B	Yu et al., 2015	The dietary factor for milk consumption by humans. The default is based on national averages.
Meat and poultry consumption	kg/yr	63	0–300	M, B	Yu et al., 2015	The dietary factor for meat and poultry consumption by humans. The default is based on national averages.
Fish consumption	kg/yr	5.4	0–1,000	M, B	Yu et al., 2015	The dietary factor for fish consumption by humans. The default is based on national averages.
Other seafood consumption	kg/yr	0.9	0–100	M, B	Yu et al., 2015	The dietary factor for other seafood consumption by humans. The default is based on national averages.
Soil ingestion	g/yr	36.5	0–10,000	M, B	Yu et al., 2015	The average annual quantity of soil ingested for the soil ingestion pathway.
Drinking water intake	L/yr	510	0–10,000	M, B	Yu et al., 2015	The drinking water ingestion rate.
Drinking water contaminated fraction	–	1	0–1	B, P	Yu et al., 2001	Allows specification of the fraction of contaminated intake for the drinking water pathway. The remaining balance (if value is less than 1) of the drinking water is from off-site sources, which are assumed to be uncontaminated. Setting the value to zero will turn off the drinking water pathway entirely.

[a] Code-accepted values are not provided for element- or nuclide-specific parameters.
[b] P = physical, B = behavioral, M = metabolic; when more than one type is listed, the first is primary and the next is secondary.
[c] "–" indicates that the parameter is dimensionless.
[d] Groundwater concentration can be input only if time since placement of material is greater than 0.
[e] This parameter should be used only if radionuclide leach rates are known.
[f] NA = not applicable.

Table A-1 Parameters and Their Default Values Used in Version 7.2 of RESRAD-ONSITE (cont.)

Parameter Name	Unit	Default Value	Code-Accepted Values[a]	Type[b]	References	Description
Ingestion Pathway, Dietary Data (cont.)						
Household water contaminated fraction	–	1	0–1	B, P	Yu et al., 2001	Allows specification of the fraction of contaminated household water for use in calculating radon exposure. The remaining balance (if value is less than1) of the household water is from off-site sources, which are assumed to be uncontaminated. The default value of 1 indicates that all household water is from an on-site source.
Livestock water contaminated fraction	–	1	0–1	B, P	Yu et al., 2001	Allows specification of the fraction of contaminated intake of livestock water for the meat and milk pathway. The remaining balance (if value is less than 1) of the livestock water is from off-site sources, which are assumed to be uncontaminated. The default value of 1 indicates that all livestock water is from an on-site source.
Irrigation water contaminated fraction	–	1	0–1	B, P	Yu et al., 2001	Allows specification of the fraction of contaminated intake of irrigation water for the plant, meat, and milk pathways. The remaining balance (if value is less than 1) of the irrigation water is from off-site sources, which are assumed to be uncontaminated. The default value of 1 indicates that all irrigation water is from an on-site source.
Aquatic food contaminated fraction	–	0.5	0–1	B, P	Yu et al., 2001	Allows specification of the fraction of contaminated intake for the fish pathway. The remaining balance is from off-site sources, which are assumed to be uncontaminated. The default value of 0.5 indicates that 50 percent of aquatic food is being obtained from on-site sources. Setting the value to 0 will turn off the fish pathway entirely.

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[b] P = physical, B = behavioral, M = metabolic; when more than one type is listed, the first is primary and the next is secondary.
[c] "–" indicates that the parameter is dimensionless.
[d] Groundwater concentration can be input only if time since placement of material is greater than 0.
[e] This parameter should be used only if radionuclide leach rates are known.
[f] NA = not applicable.

Table A-1 Parameters and Their Default Values Used in Version 7.2 of RESRAD-ONSITE (cont.)

Parameter Name	Unit	Default Value	Code-Accepted Values[a]	Type[b]	References	Description
Ingestion Pathway, Dietary Data (cont.)						
Plant food contaminated fraction	–	-1	0–1 or -1	B, P	Yu et al., 2001	Allows specification of the fraction of contaminated intake for the plant pathway. The appropriate values range from 0 to 1, although a negative value can be input. The remaining balance is from off-site sources, which are assumed to be uncontaminated. The default value of -1 specifies that the contaminated fraction of plant food will be calculated from the appropriate area factor in the code. Setting the value to 0 will turn off the plant pathway entirely.
Meat contaminated fraction	–	-1	0–1 or –1	B, P	Yu et al., 2001	Allows specification of the fraction of contaminated intake for the meat pathway. The appropriate values range from 0 to 1, although a negative value can be input. The remaining balance is from off-site sources, which are assumed to be uncontaminated. The default value of -1 specifies that the contaminated fraction of meat will be calculated from the appropriate area factor in the code. Setting the value to 0 will turn off the meat pathway entirely.
Milk contaminated fraction	–	-1	0–1 or –1	B, P	Yu et al., 2001	Allows specification of the fraction of contaminated intake for the milk pathway. The appropriate values range from 0 to 1, although a negative value can be input. The remaining balance is from off-site sources, which are assumed to be uncontaminated. The default value of -1 specifies that the contaminated fraction of milk will be calculated from the appropriate area factor in the code. Setting the value to 0 will turn off the milk pathway entirely.

[a] Code-accepted values are not provided for element- or nuclide-specific parameters.
[b] P = physical, B = behavioral, M = metabolic; when more than one type is listed, the first is primary and the next is secondary.
[c] "–" indicates that the parameter is dimensionless.
[d] Groundwater concentration can be input only if time since placement of material is greater than 0.
[e] This parameter should be used only if radionuclide leach rates are known.
[f] NA = not applicable.

Table A-1 Parameters and Their Default Values Used in Version 7.2 of RESRAD-ONSITE (cont.)

Parameter Name	Unit	Default Value	Code-Accepted Values[a]	Type[b]	References	Description
Ingestion Pathway, Nondietary Data						
Livestock fodder intake for meat	kg/d	68	0–300	M	Sprung et al., 1990	The daily intake of fodder by livestock kept for meat consumption. The code uses the area factor to calculate the contaminated intake.
Livestock fodder intake for milk	kg/d	55	0–300	M	Sprung et al., 1990	The daily intake of fodder by livestock kept for milk consumption. The code uses the area factor to calculate the contaminated intake.
Livestock water intake for meat	L/d	50	0–500	M	Yu et al., 2015	The daily intake of water by livestock kept for meat consumption. The code uses the area factor to calculate the contaminated intake.
Livestock water intake for milk	L/d	160	0–500	M	Yu et al., 2015	The daily intake of water by livestock kept for milk consumption. The code uses the area factor to calculate the contaminated intake.
Livestock intake of soil	kg/d	0.5	0–10	M	Yu et al., 2015	The daily intake of soil by livestock kept for meat or milk consumption.
Mass loading for foliar deposition	g/m^3	1.00E-04	0–1	P	Gilbert et al., 1983	The average mass loading of airborne contaminated soil particles in a garden during the growing season.
Depth of soil mixing layer	m	0.15	0–1	P	Yu et al., 2001	Used in calculating the depth factor for dust inhalation and soil ingestion pathways and for foliar deposition for the plant, meat, and milk ingestion pathways. The depth factor is the fraction of the resuspendable soil particles at the ground surface that are contaminated. It is calculated by assuming that mixing of soil will occur in the soil mixing layer.
Depth of roots	m	0.9	0–100	P	Yu et al., 2015	The maximum root depth below the ground surface. The code uses the depth of roots that interact with the contaminated zone to calculate the plant concentration.

[a] Code-accepted values are not provided for element- or nuclide-specific parameters.
[b] P = physical, B = behavioral, M = metabolic; when more than one type is listed, the first is primary and the next is secondary.
[c] "–" indicates that the parameter is dimensionless.
[d] Groundwater concentration can be input only if time since placement of material is greater than 0.
[e] This parameter should be used only if radionuclide leach rates are known.
[f] NA = not applicable.

Table A-1 Parameters and Their Default Values Used in Version 7.2 of RESRAD-ONSITE (cont.)

Parameter Name	Unit	Default Value	Code-Accepted Values[a]	Type[b]	References	Description
Ingestion Pathway, Nondietary Data (cont.)						
Groundwater fractional usage for drinking water	–	1	0–1	B, P	Yu et al., 2001	This is the fraction of contaminated water from the site used for drinking that is obtained from the well. The complementary fraction of contaminated water is obtained from surface water body.
Groundwater fractional usage for household water	–	1	0–1	B, P	Yu et al., 2001	This is the fraction of contaminated water from the site used for the household that is obtained from the well. The complementary fraction of contaminated water is obtained from surface water body.
Groundwater fractional usage for livestock water	–	1	0–1	B, P	Yu et al., 2001	This is the fraction of contaminated water from the site used for livestock that is obtained from the well. The complementary fraction of contaminated water is obtained from surface water body.
Groundwater fractional usage for irrigation water	–	1	0–1	B, P	Yu et al., 2001	This is the fraction of contaminated water from the site used for irrigation that is obtained from the well. The complementary fraction of contaminated water is obtained from surface water body.
Plant Factors						
Wet-weight crop yields – nonleafy	kg/m^2	0.7	0.01–3	P	USDA 1997; Beyeler et al., 1998	The weight of the edible portion of plant food produced per unit land area for different food classes. The code has wet-weight crop yield for nonleafy, leafy, and fodder. Nonleafy and leafy vegetables are for human consumption; fodder is for animal consumption.
Wet-weight crop yields – leafy	kg/m^2	1.5	0.01–3	P	USDA 1997; Beyeler et al., 1998	The weight of the edible portion of plant food produced per unit land area for different food classes. The code has wet-weight crop yield for nonleafy, leafy, and fodder. Nonleafy and leafy vegetables are for human consumption; fodder is for animal consumption.
Wet-weight crop yields - fodder	kg/m^2	1.1	0.01–3	P	USDA 1997; Beyeler et al., 1998	

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[c] "–" indicates that the parameter is dimensionless.
[d] Groundwater concentration can be input only if time since placement of material is greater than 0.
[e] This parameter should be used only if radionuclide leach rates are known.
[f] NA = not applicable.

Table A-1 Parameters and Their Default Values Used in Version 7.2 of RESRAD-ONSITE (cont.)

Parameter Name	Unit	Default Value	Code-Accepted Values[a]	Type[b]	References	Description
Plant Factors (cont.)						
Length of growing season – nonleafy	yr	0.17(nonleafy)	0.01–1	P	USDA 1997; Beyeler et al., 1998	The exposure time to contamination for the plant food during the growing season. The contamination can reach the edible portion of the plant food through foliar deposition, root uptake, and water irrigation. The code has length of growing season for nonleafy vegetables, leafy vegetables, and fodder.
Length of growing season – leafy	yr	0.25	0.01–1	P	USDA 1997; Beyeler et al., 1998	The exposure time to contamination for the plant food during the growing season. The contamination can reach the edible portion of the plant food through foliar deposition, root uptake, and water irrigation. The code has length of growing season for nonleafy vegetables, leafy vegetables, and fodder.
Length of growing season – fodder	yr	0.08	0.01–1	P	USDA 1997; Beyeler et al., 1998	The exposure time to contamination for the plant food during the growing season. The contamination can reach the edible portion of the plant food through foliar deposition, root uptake, and water irrigation. The code has length of growing season for nonleafy vegetables, leafy vegetables, and fodder.
Translocation factor – nonleafy	–	0.1	0–1	P	IAEA 1994; Snyder et al., 1994	The fraction of the contamination that is retained on the foliage that is transferred to the edible portion of the plant. The code has three food categories: nonleafy (includes nonleafy vegetables, fruit, and grain) and leafy vegetables for humans; and fodder for animal consumption.

[a] Code-accepted values are not provided for element- or nuclide-specific parameters.
[b] P = physical, B = behavioral, M = metabolic; when more than one type is listed, the first is primary and the next is secondary.
[c] "–" indicates that the parameter is dimensionless.
[d] Groundwater concentration can be input only if time since placement of material is greater than 0.
[e] This parameter should be used only if radionuclide leach rates are known.
[f] NA = not applicable.

Table A-1 Parameters and Their Default Values Used in Version 7.2 of RESRAD-ONSITE (cont.)

Parameter Name	Unit	Default Value	Code-Accepted Values[a]	Type[b]	References	Description
Plant Factors (cont.)						
Translocation factor – leafy and fodder	–	1	0–1	P	IAEA 1994; Snyder et al., 1994	The fraction of the contamination that is retained on the foliage that is transferred to the edible portion of the plant. The code has three food categories: nonleafy (includes nonleafy vegetables, fruit, and grain) and leafy vegetables for human and fodder for animal consumption.
Weathering removal constant	1/yr	20	1–40	P	IAEA 1994; Snyder et al., 1994	The weathering process would remove contaminants from foliage of the plant food. The process is characterized by a removal constant and reduces the amount of contaminants on foliage exponentially during the exposure period.
Wet foliar interception fraction	–	0.25 (nonleafy, leafy, and fodder)	0–1	P	IAEA 1994	The fraction of deposited radionuclides that is retained on the foliage of the plant food. Both dry deposition (from airborne particulates) and the wet deposition processes (from irrigation) are considered. The code has a wet as well as dry foliar interception fraction for nonleafy, leafy (for human consumption), and fodder (for animal consumption).
Dry foliar interception fraction	–	0.25 (nonleafy, leafy, and fodder)	0–1	P	IAEA 1994; Snyder et al., 1994	The fraction of deposited radionuclides that is retained on the foliage of the plant food. Both the dry deposition (from airborne particulates) and the wet deposition processes (from irrigation) are considered. The code has a wet as well as dry foliar interception fraction for nonleafy, leafy (for human consumption), and fodder (for animal consumption).

[a] Code-accepted values are not provided for element- or nuclide-specific parameters.
[b] P = physical, B = behavioral, M = metabolic; when more than one type is listed, the first is primary and the next is secondary.
[c] "–" indicates that the parameter is dimensionless.
[d] Groundwater concentration can be input only if time since placement of material is greater than 0.
[e] This parameter should be used only if radionuclide leach rates are known.
[f] NA = not applicable.

Table A-1 Parameters and Their Default Values Used in Version 7.2 of RESRAD-ONSITE (cont.)

Parameter Name	Unit	Default Value	Code-Accepted Values[a]	Type[b]	References	Description
Radon Data						
Cover total porosity	–	0.4	0–1	P	Yu et al., 2015	The ratio of the void space volume to the total volume of the porous medium.
Cover volumetric water content	–	0.05	0–1	P	Yu et al., 2015	The fraction of the total volume of the porous medium that is occupied by water.
Cover radon diffusion coefficient	m^2/s	2.00E-06	0–1 or -1	P	Yu et al., 2001	The effective (or interstitial) radon diffusion coefficient is the ratio of the diffusive flux density of radon activity across the pore area to the gradient of the radon activity concentration in the pore space. Entering –1 for any diffusion coefficient will cause the code to calculate the diffusion coefficient based on the porosity and water content of the medium.
Building foundation thickness	m	0.15	0–10	P	Yu et al., 2015	Average thickness of the building shell structure in the subsurface of the soil.
Building foundation density	g/cm^3	2.4	0–100	P	Yu et al., 2015	The mass of solid phase to the total volume.
Building foundation total porosity	–	0.1	1E-4–1	P	Yu et al., 2015	See “Cover total porosity” (above).
Building foundation volumetric water content	–	0.03	0–1	P	Yu et al., 2015	See “Cover volumetric water content” (above).
Building foundation radon diffusion coefficient	m^2/s	3.00E-07	0–1 or -1	P	Yu et al., 2015	See “Cover radon diffusion coefficient” (above).
Contaminated radon diffusion coefficient	m^2/s	2.00E-06	0–1 or -1	P	Yu et al., 2015	Diffusion coefficient of radon in contaminated zone.
Radon vertical dimension of mixing	m	2	1E-4–1,000	P	Yu et al., 2015	The height into which the plume of radon is uniformly mixed in the outdoor air.

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[b] P = physical, B = behavioral, M = metabolic; when more than one type is listed, the first is primary and the next is secondary.
[c] “–” indicates that the parameter is dimensionless.
[d] Groundwater concentration can be input only if time since placement of material is greater than 0.
[e] This parameter should be used only if radionuclide leach rates are known.
[f] NA = not applicable.

Table A-1 Parameters and Their Default Values Used in Version 7.2 of RESRAD-ONSITE (cont.)

Parameter Name	Unit	Default Value	Code-Accepted Values[a]	Type[b]	References	Description
Radon Data (cont.)						
Building air exchange rate	1/h	0.5	0–1,000	P, B	Yu et al., 2015	The building exchange rate (or ventilation) is defined as the number of the total volumes of air contained in the building being exchanged with outside air per unit of time.
Building room height	m	2.5	1E-4–100	P	Yu et al., 2015	The average height of rooms in the building.
Building indoor area factor	–	0	0–100	P	Yu et al., 2015	The fraction of the area built on the contaminated soil. Values greater than 1 indicate contribution from adjacent walls. A default value of 0 is assumed, which forces the code to calculate this time dependent area factor by assuming floor area of 100 m^2 and walls extending into the contaminated area. This factor is time dependent because of erosion.
Foundation depth below ground surface	m	-1	0–100 or -1	P	Yu et al., 2015	The vertical distance in the soil immediately from the bottom of the basement floor slab to the ground surface. A default value of –1 is used in the code; in this case the code adjusts the depths so that the foundation depth will not extend into the contaminated zone at each of the times at which a dose is computed.
Radon-222 emanation coefficient	–	0.25	0.01–1	P	Yu et al., 2015	The fraction of the total radon generated by radium decay that escapes soil. (Depends on such parameters as porosity, particle size distribution, mineralogy, and moisture content.)
Radon-220 emanation coefficient	–	0.15	0.01–1	P	Yu et al., 2015	See “Radon-222 emanation coefficient” (above).

[a] Code-accepted values are not provided for element- or nuclide-specific parameters.
[b] P = physical, B = behavioral, M = metabolic; when more than one type is listed, the first is primary and the next is secondary.
[c] “–” indicates that the parameter is dimensionless.
[d] Groundwater concentration can be input only if time since placement of material is greater than 0.
[e] This parameter should be used only if radionuclide leach rates are known.
[f] NA = not applicable.

Table A-1 Parameters and Their Default Values Used in Version 7.2 of RESRAD-ONSITE (cont.)

Parameter Name	Unit	Default Value	Code-Accepted Values[a]	Type[b]	References	Description
Storage Times before Use Data						
Storage times for fruits, nonleafy vegetables, and grain	d	14	0–1E+34	B	Snyder et al., 1994	The storage times are used to calculate radioactive ingrowth and decay adjustment factors for food and feed due to storage. The code has values for fruits, nonleafy vegetables, and grain; leafy vegetables; milk; well water; surface water; livestock fodder; meat; fish; and Crustacea, and mollusks.
Storage times for leafy vegetables	d	1	0–1E+34	B	Snyder et al., 1994	See above.
Storage times for milk	d	1	0–1E+34	B	Snyder et al., 1994	See above.
Storage times for meat	d	20	0–1E+34	B	Snyder et al., 1994	See above.
Storage times for fish	d	7	0–1E+34	B	Snyder et al., 1994	See above.
Storage times for Crustacea and mollusks	d	7	0–1E+34	B	Snyder et al., 1994	See above.
Storage times for well water	d	1	0–1E+34	B	Snyder et al., 1994	See above.
Storage times for surface water	d	1	0–1E+34	B	Snyder et al., 1994	See above.
Storage times for livestock fodder	d	45	0–1E+34	B	Snyder et al., 1994	For livestock fodder, the storage time is an annual average. The default value is obtained by assuming 6 months of outside grazing and 6 months of silage fodder with an average silo time of 3 months.
Carbon-14 Data						
C-12 concentration in local water	g/cm^3	2.00E-05	0–100	P	Yu et al., 2001	The stable carbon concentration in water.
C-12 concentration in contaminated soil	g/g	0.03	1E-4–1	P	Yu et al., 2001	The stable carbon concentration in contaminated soil.

[a] Code-accepted values are not provided for element- or nuclide-specific parameters.
[b] P = physical, B = behavioral, M = metabolic; when more than one type is listed, the first is primary and the next is secondary.
[c] "–" indicates that the parameter is dimensionless.
[d] Groundwater concentration can be input only if time since placement of material is greater than 0.
[e] This parameter should be used only if radionuclide leach rates are known.
[f] NA = not applicable.

Table A-1 Parameters and Their Default Values Used in Version 7.2 of RESRAD-ONSITE (cont.)

Parameter Name	Unit	Default Value	Code-Accepted Values[a]	Type[b]	References	Description
Carbon-14 Data (cont.)						
Fraction of vegetation carbon absorbed from soil	–	0.02	1E-4–1	P	Yu et al., 2001	The fraction of total vegetation carbon obtained by direct root uptake from the soil.
Fraction of vegetation carbon absorbed from air	–	0.98	0–1	P	Yu et al., 2001	The fraction of total vegetation carbon assimilated from the atmosphere through photosynthesis.
Thickness of evasion layer of C-14 in soil	m	0.3	0–10	P	Yu et al., 2001	The maximum soil thickness layer through which C-14 can escape to the air by conversion to CO_2. C-14 below this depth is assumed to be trapped.
C-14 evasion flux rate from soil	1/s	7.00E-07	0–1	P	Sheppard et al., 1991	The fraction of the soil inventory of C-14 that is lost to the atmosphere per unit time.
C-12 evasion flux rate from soil	1/s	1.00E-10	0–1	P	Amiro et al., 1991	The fraction of C-12 in soil that escapes to the atmosphere per unit time.
Grain fraction in livestock feed – beef cattle	–	0.8	0–1	B	Amiro et al., 1991	The fraction of grain (nonleafy) vegetation in the livestock diet. The balance is assumed to be leafy vegetation: hay or fodder.
Grain fraction in livestock feed – cow	–	0.2	0–1	B	Amiro et al., 1991	The fraction of grain (nonleafy) vegetation in the livestock diet. The balance is assumed to be leafy vegetation: hay or fodder.

[a] Code-accepted values are not provided for element- or nuclide-specific parameters.
[b] P = physical, B = behavioral, M = metabolic; when more than one type is listed, the first is primary and the next is secondary.
[c] "–" indicates that the parameter is dimensionless.
[d] Groundwater concentration can be input only if time since placement of material is greater than 0.
[e] This parameter should be used only if radionuclide leach rates are known.
[f] NA = not applicable.

Table A-2 RESRAD-ONSITE V7.2 and RESRAD-OFFSITE V4.0 Default Value and Distribution for the Distribution Coefficient, K_d Parameter for Different Elements

Element	Deterministic Default DistributionCoefficient, K_d (cm^3/g or L/kg)	Lognormal Distribution[a]	
		μ	σ
Ac	20	6.72	3.22
Ag	0	5.38	2.1
Al	0	6.45	3.22
Am	20	7.28	3.15
As	114	NA[b]	NA
At	0	NA	NA
Au	0	4.65	3.22
Ba	50	6.33	3.22
Be	810	NA	NA
Bi	0	4.65	3.22
Bk	70	NA	NA
Br	49	NA	NA
C	0	2.4	3.22
Ca	50	1.4	0.78
Cd	0	3.52	2.99
Ce	1,000	7.6	2.08
Cf[c]	1,380	7.23	3.22
Cl	0.1	1.68	3.22
Cm[c]	1,380	8.82	1.82
Co	1,000	5.46	2.53
Cr	30	4.63	2.76
Cs	4,600	6.1	2.33
Cu	333	NA	NA
Dy[c]	935	NA	NA
Er[c]	935	NA	NA
Es[c]	1,380	NA	NA
Eu[c]	825	6.72	3.22
F[c]	257	NA	NA

[a] Source: Yu et al., 2000

[b] NA = not applicable.

[c] RESRAD-ONSITE V7.2 uses Plant/Soil ratio to estimate K_d value. RESRAD-OFFSITE V4.0 does not have the root uptake transfer factor correlation as an option for estimating the distribution. The values that RESRAD-ONSITE computes using the correlation are the default inputs for RESRAD-OFFSITE.

Note: μ is mean of the underlying normal distribution and σ is standard deviation of underlying normal distribution.

Table A-2 RESRAD-ONSITE V7.2 and RESRAD-OFFSITE V4.0 Default Value and Distribution for the Distribution Coefficient, K_d Parameter for Different Elements (cont.)

Element	Deterministic Default DistributionCoefficient, K_d (cm^3/g or L/kg)	Lognormal Distribution[a]	
		μ	σ
Fe	1,000	5.34	2.67
Fm[c]	935	NA	NA
Fr	200	NA	NA
Ga[c]	745	NA	NA
Gd[c]	825	6.72	3.22
Ge	0	3.87	3.22
H	0	-2.81	0.5
Hf	1,500	NA	NA
Hg	52	NA	NA
Ho	800	NA	NA
I	0.1	1.52	2.19
In	158	NA	NA
Ir	0	5.32	3.22
K	5.5	1.7	0.49
La	4.98	NA	NA
Lu[c]	935	NA	NA
Md[c]	935	NA	NA
Mg	63	NA	NA
Mn	200	5.06	2.29
Mo	125	NA	NA
Na	10	5.04	3.22
Nb	0	5.94	3.22
Nd	158	NA	NA
Ni	1,000	6.05	1.46
Np[c]	257	2.84	2.25
Os	157	NA	NA
P	30	NA	NA
Pa	50	5.94	3.22

[a] Source: Yu et al., 2000

[b] NA = not applicable.

[c] RESRAD-ONSITE V7.2 uses Plant/Soil ratio to estimate K_d value. RESRAD-OFFSITE V4.0 does not have the root uptake transfer factor correlation as an option for estimating the distribution. The values that RESRAD-ONSITE computes using the correlation are the default inputs for RESRAD-OFFSITE.

Note: μ is mean of the underlying normal distribution and σ is standard deviation of underlying normal distribution.

Table A-2 RESRAD-ONSITE V7.2 and RESRAD-OFFSITE V4.0 Default Value and Distribution for the Distribution Coefficient, K_d Parameter for Different Elements (cont.)

Element	Deterministic Default DistributionCoefficient, K_d (cm^3/g or L/kg)	Lognormal Distribution[a]	
		μ	σ
Pb	100	7.78	2.76
Pd	180	NA	NA
Pm[c]	825	6.72	3.22
Po	10	5.2	1.68
Pr	157	NA	NA
Pt	24	NA	NA
Pu	2,000	6.86	1.89
Ra	70	8.17	1.7
Rb	125	NA	NA
Re	43.5	NA	NA
Rh	4	NA	NA
Rn	0	NA	NA
Ru	0	7.37	3.13
S	0	3.65	3.22
Sb	0	5.94	3.22
Sc	0	6.84	3.22
Se	0	4.73	0.57
Si	110	NA	NA
Sm[c]	825	6.72	3.22
Sn	0	6.72	3.22
Sr	30	3.45	2.12
Ta	0	5.55	3.22
Tb	157	NA	NA
Tc	0	-0.67	3.16
Te	0	3.64	3.22
Th	60,000	8.68	3.62
Ti[c]	1,380	NA	NA
Tl	0	4.26	3.22

[a] Source: Yu et al., 2000

[b] NA = not applicable.

[c] RESRAD-ONSITE V7.2 uses Plant/Soil ratio to estimate K_d value. RESRAD-OFFSITE V4.0 does not have the root uptake transfer factor correlation as an option for estimating the distribution. The values that RESRAD-ONSITE computes using the correlation are the default inputs for RESRAD-OFFSITE.

Note: μ is mean of the underlying normal distribution and σ is standard deviation of underlying normal distribution.

Table A-2 RESRAD-ONSITE V7.2 and RESRAD-OFFSITE V4.0 Default Value and Distribution for the Distribution Coefficient, K_d Parameter for Different Elements (cont.)

Element	Deterministic Default DistributionCoefficient, K_d (cm^3/g or L/kg)	Lognormal Distribution[a]	
		μ	σ
Tl	0	4.26	3.22
Tm[c]	935	NA	NA
U	50	4.84	3.13
V[c]	935	NA	NA
W	157	NA	NA
Y	720	NA	NA
Yb[c]	935	NA	NA
Zn	0	6.98	4.44
Zr	2,200	7.23	3.22

[a] Source: Yu et al., 2000

[b] NA = not applicable.

[c] RESRAD-ONSITE V7.2 uses Plant/Soil ratio to estimate K_d value. RESRAD-OFFSITE V4.0 does not have the root uptake transfer factor correlation as an option for estimating the distribution. The values that RESRAD-ONSITE computes using the correlation are the default inputs for RESRAD-OFFSITE.

Note: μ is mean of the underlying normal distribution and σ is standard deviation of underlying normal distribution.

Table A-3 Transfer Factors for Plants, Meat, and Milk in RESRAD-ONSITE V7.2 and RESRAD-OFFSITE V4.0

Element	Plant (pCi/g-plant)/(pCi/g-soil)	Meat (pCi/kg)/(pCi/d)	Milk (pCi/L)/(pCi/d)
Ac	2.50E-03	2.00E-05	2.00E-05
Ag	1.50E-01	3.00E-03	2.50E-02
Al	4.00E-03	5.00E-04	2.00E-04
Am	1.00E-03	5.00E-05	2.00E-06
Ar	0	0	0
As	8.00E-02	1.50E-03	1.00E-04
At	2.00E-01	1.00E-02	1.00E-02
Au	1.00E-01	5.00E-03	1.00E-05
Ba	5.00E-03	2.00E-04	5.00E-04
Be	4.00E-03	1.00E-03	2.00E-06
Bi	1.00E-01	2.00E-03	5.00E-04
Bk	1.00E-03	2.00E-05	2.00E-06
Br	7.60E-01	2.00E-02	2.00E-02
C	5.5	3.10E-02	1.20E-02
Ca	5.00E-01	1.60E-03	3.00E-03
Cd	3.00E-01	4.00E-04	1.00E-03
Ce	2.00E-03	2.00E-05	3.00E-05
Cf	1.00E-03	6.00E-05	7.50E-07
Cl	20	6.00E-02	2.00E-02
Cm	1.00E-03	2.00E-05	2.00E-06
Co	8.00E-02	2.00E-02	2.00E-03
Cr	2.50E-04	9.00E-03	2.00E-03
Cs	4.00E-02	3.00E-02	8.00E-03
Cu	1.30E-01	1.00E-02	2.00E-03
Dy	2.00E-03	2.00E-03	6.00E-05
Er	2.00E-03	2.00E-03	6.00E-05
Es	1.00E-03	2.00E-05	2.00E-06
Eu	2.50E-03	2.00E-03	5.00E-05
F	2.00E-02	2.00E-02	7.00E-03
Fe	1.00E-03	2.00E-02	3.00E-04
Fm	2.00E-03	2.00E-04	8.00E-06
Fr	3.00E-02	3.00E-02	8.00E-03
Ga	3.00E-03	3.00E-04	1.00E-05
Gd	2.50E-03	2.00E-03	2.00E-05
Ge	4.00E-01	2.00E-01	1.00E-02
H	4.8	1.20E-02	1.00E-02
Hf	3.00E-03	4.00E-04	2.00E-05
Hg	3.80E-01	1.00E-01	5.00E-04

Source: Yu et al., 2015 (Tables 6.3.10, 6.4.2, and 6.5.1).

Table A-3 Transfer Factors for Plants, Meat, and Milk in RESRAD-ONSITE V7.2 and RESRAD-OFFSITE V4.0 (cont.)

Element	Plant (pCi/g-plant)/(pCi/g-soil)	Meat (pCi/kg)/(pCi/d)	Milk (pCi/L)/(pCi/d)
Ho	2.60E-03	2.00E-03	2.00E-05
I	2.00E-02	7.00E-03	1.00E-02
In	3.00E-03	4.00E-03	2.00E-04
Ir	3.00E-02	2.00E-03	2.00E-06
K	3.00E-01	2.00E-02	7.00E-03
Kr	0	0	0
La	2.50E-03	2.00E-03	2.00E-05
Lu	2.00E-03	2.00E-03	6.00E-05
Mg	3.00E-02	3.00E-03	8.00E-03
Mn	3.00E-01	5.00E-04	3.00E-04
Mo	1.30E-01	1.00E-03	1.70E-03
N	7.5	1.00E-01	1.00E-01
Na	5.00E-02	8.00E-02	4.00E-02
Nb	1.00E-02	3.00E-07	2.00E-06
Nd	2.40E-02	2.00E-03	2.00E-05
Ne	0	0	0
Ni	5.00E-02	5.00E-03	2.00E-02
Np	2.00E-02	1.00E-03	5.00E-06
O	6.00E-01	2.00E-01	2.00E-02
Os	3.00E-02	2.00E-03	1.00E-04
P	1	5.00E-02	1.60E-02
Pa	1.00E-02	5.00E-03	5.00E-06
Pb	1.00E-02	8.00E-04	3.00E-04
Pd	1.00E-02	8.00E-04	3.00E-04
Pm	2.50E-03	2.00E-03	2.00E-05
Po	1.00E-03	5.00E-03	3.40E-04
Pr	2.50E-03	2.00E-02	2.00E-05
Pt	1.00E-01	2.00E-04	1.00E-04
Pu	1.00E-03	1.00E-04	1.00E-06
Ra	4.00E-02	1.00E-03	1.00E-03
Rb	1.30E-01	1.50E-02	1.00E-02
Re	2.00E-01	1.00E-02	2.00E-03
Rh	1.30E-01	1.00E-03	5.00E-03
Rn	0	0	0
Ru	3.00E-02	2.00E-03	3.30E-06
S	6.00E-01	2.00E-01	2.00E-02
Sb	1.00E-02	1.00E-03	1.00E-04
Sc	2.00E-03	1.50E-02	5.00E-06

Source: Yu et al., 2015 (Tables 6.3.10, 6.4.2, and 6.5.1).

Table A-3 Transfer Factors for Plants, Meat, and Milk in RESRAD-ONSITE V7.2 and RESRAD-OFFSITE V4.0 (cont.)

Element	Plant (pCi/g-plant)/(pCi/g-soil)	Meat (pCi/kg)/(pCi/d)	Milk (pCi/L)/(pCi/d)
Se	1.00E-01	1.00E-01	1.00E-02
Si	2.00E-02	3.00E-04	2.00E-05
Sm	2.50E-03	2.00E-03	2.00E-05
Sn	2.50E-03	1.00E-02	1.00E-03
Sr	3.00E-01	8.00E-03	2.00E-03
Ta	2.00E-02	5.00E-06	5.00E-06
Tb	2.60E-03	2.00E-03	2.00E-05
Tc	5	1.00E-04	1.00E-03
Te	6.00E-01	7.00E-03	5.00E-04
Th	1.00E-03	1.00E-04	5.00E-06
Ti	1.00E-03	2.00E-02	1.00E-02
Tl	2.00E-01	2.00E-02	3.00E-03
Tm	2.00E-03	2.00E-03	6.00E-05
U	2.50E-03	3.40E-04	6.00E-04
V	2.00E-03	1.00E-02	5.00E-04
W	1.80E-02	4.00E-02	3.00E-04
Xe	0	0	0
Y	2.50E-02	2.00E-03	2.00E-05
Yb	2.00E-03	2.00E-03	6.00E-05
Zn	4.00E-01	1.00E-01	1.00E-02
Zr	1.00E-03	1.00E-06	6.00E-07

Source: Yu et al., 2015 (Tables 6.3.10, 6.4.2, and 6.5.1).

Table A-4 Bioaccumulation Factors for Fish, and Crustacea and Mollusks in RESRAD-ONSITE V7.2 and RESRAD-OFFSITE V4.0

Element	Fish (pCi/kg)/(pCi/L)	Crustacea and Mollusks (pCi/kg)/(pCi/L)	Element	Fish (pCi/kg)/(pCi/L)	Crustacea and Mollusks (pCi/kg)/(pCi/L)
Ac	15	1,000	Mn	400	90000
Ag	5	770	Mo	10	10
Al	500	1,000	N	150,000	0
Am	30	1,000	Na	20	200
As	300	300	Nb	300	100
At	15	-1	Nd	100	1,000
Au	35	1,000	Ni	100	100
Ba	4	200	Np	30	400
Be	100	10	O	1	-1

Source: Yu et al., 2015 (Tables 6.6.1 and 6.6.3).

Table A-4 Bioaccumulation Factors for Fish, and Crustacea and Mollusks in RESRAD-ONSITE V7.2 and RESRAD-OFFSITE V4.0 (cont.)

Element	Fish (pCi/kg)/(pCi/L)	Crustacea and Mollusks (pCi/kg)/(pCi/L)	Element	Fish (pCi/kg)/(pCi/L)	Crustacea and Mollusks (pCi/kg)/(pCi/L)
Bi	15	10	Os	35	-1
Bk	25	-1	P	50,000	20,000
Br	420	330	Pa	10	110
C	50,000	9,100	Pb	300	100
Ca	1.000	330	Pd	10	300
Cd	200	2,000	Pm	30	1,000
Ce	30	1,000	Po	100	20,000
Cf	25	1,000	Pr	100	1,000
Cl	1,000	190	Pt	35	-1
Cm	30	1,000	Pu	30	100
Co	300	200	Ra	50	250
Cr	200	2000	Rb	2,000	1,000
Cs	2,000	100	Re	12,000	-1
Cu	200	400	Rh	10	300
Dy	25	-1	Ru	10	300
Er	12,000	-1	S	1,000	240
Es	25	-1	Sb	100	10
Eu	50	1,000	Sc	100	1,000
F	10	100	Se	200	170
Fe	200	3,200	Si	20	-1
Fm	10	-1	Sm	25	1,000
Fr	30	-1	Sn	3,000	1,000
Ga	400	-1	Sr	60	100
Gd	25	1,000	Ta	100	30
Ge	4,000	20,000	Tb	25	1,000
H	1	1	Tc	20	5
Hf	40	-1	Te	400	75
Hg	1,000	20,000	Th	100	500
Ho	25	1,000	Ti	1,000	-1
I	40	5	Tl	10,000	15,000
In	10,000	15,000	Tm	25	-1
Ir	10	200	U	10	60
K	1,000	200	V	200	3,000
Kr	0	0	W	1,200	10
La	30	1,000	Y	30	1,000
Lu	25	-1	Yb	200	-1
Md	10	-1	Zn	1,000	10,000
Mg	50	100	Zr	300	6.7

Source: Yu et al., 2015 (Tables 6.6.1 and 6.6.3).

Table A-5 Parameters and Their Default Values Used in RESRAD-OFFSITE V4.0

Input Screen Title and Parameter Name	Units	Default Value[a]	Code-Accepted Values[b] Physical or Numerical[c] (N) Range	Type[d]	Description
Title & Radiological Data					
Title	–[e]	RESRAD-OFFSITE Default Parameters	80 alphabetic or numeric characters	NA[f]	The Title is used to identify the run and can be up to 80 alphabetic or numeric characters long.
Location of dose, slope, and transfer factor database	–	C:\RESRAD_Family\DCF\3.1	–	NA	This parameter specifies the directory of dose, slope, and transfer factor database on the computer.
Radionuclide transformation based on	–	ICRP 107	ICRP 107, ICRP 38	NA	This is the name of the radionuclide transformation database containing radionuclide transformation based on ICRP 107.
External exposure library	–	DCFPAK 3.02	DCFPAK 3.02, FGR 13, FGR 12, user specified	NA	This library is selected based on the selection for internal exposure dose library.
Internal exposure dose library	–	DOE STD-1196-2011 (Reference Person)	DOE STD-1196-2011 (Reference Person) DCFPAK 3.02 - Adult DCFPAK 3.02 - Infant DCFPAK 3.02 - Age 1 DCFPAK 3.02 - Age 5 DCFPAK 3.02 - Age 10 DCFPAK 3.02 - Age 15 ICRP-72 - Adult ICRP-72 - Infant ICRP-72 - Age 1; ICRP-72 - Age 5; ICRP-72 - Age 10; ICRP-72 - Age 15; FGR-11, user specified	NA	This is the name of the internal dose conversion factor library for the RESRAD-OFFSITE V4.0.
Slope factor (risk) library	–	DCFPAK 3.02 Morbidity	DCFPAK 3.02 morbidity DCFPAK 3.02 mortality FGR-13 morbidity FGR-13 mortality or HEAST 2001 morbidity	NA	This is the name of the slope factor library containing all slope factors for the RESRAD-OFFSITE V4.0 pathways.

a The default values listed in this table are the default values in the RESRAD-OFFSITE V4.0.
b Code-accepted values are not provided for element- or nuclide-specific parameters.
c Numerical range is the range defined in a program file to prevent code crashes.
d P = physical, B = behavioral, M = metabolic; when more than one type is listed, the first is primary and the next is secondary.
e "–" indicates that the parameter is dimensionless.
f NA = not applicable.

Table A-5 Parameters and Their Default Values Used in RESRAD-OFFSITE V4.0 (cont.)

Input Screen Title and Parameter Name	Units	Default Value[a]	Code-Accepted Values[b] Physical or Numerical[c] (N) Range	Type[d]	Description
Title & Radiological Data (cont.)					
Transfer factor library	–	RESRAD default transfer factors	RESRAD default transfer factors,user specified	NA	This is the name of the transfer factor library for the RESRAD-OFFSITE V4.0.
Cutoff half-life	–	30 days	≥10 minutes	NA	This is the cutoff half-life used to separate the “principal nuclides” from the “associated nuclides.”
Number of intermediate time points	–	2048	32, 64, 128, 256, 512, 1024, 2048, 4096, 8192, 16384, 22000	NA	This parameter specifies the number of graphic points. It affects the precision of the computed results and the smoothness of the output graphic curves.
Spacing between intermediate time points	–	Linear	Linear/Log	NA	Linear or Log is used to specify the type of spacing (years) between the generated time points.
Minimum time increment between intermediate time points	–	1	1/1, 1/2, 1/4, 1/8, 1/16, 1/32, 1/64, 1/128, 1/256, 1/512, 1/1,024, 1/2,048, 1/4,096	NA	This is the lowest time interval allowed between two intermediate time points. It is also used to determine the second intermediate time point.
Update progress of computation message	s	0	0, 1, 2, 4, 15, 30, 60, 900	NA	An interface parameter that specifies how frequently the progress of computation is to be reported and displayed on the screen.
Use line draw character	–	Yes	Yes/No	NA	Use line-draw character set in the report files.
Preliminary Inputs					
Radiological units for activity	–	pCi	Ci, Bq, dps, dpm	NA	Any of the four units of radioactivity: Curie (Ci), Becquerel (Bq), disintegrations per second (dps), or disintegrations per minute (dpm) can be selected. Any standard one-character metric prefix can be used with Ci and Bq.
Radiological units for dose	–	mrem	rem, Sv	NA	Both conventional and SI units may be selected for radiation dose. Any standard one-character metric prefix can be used with rem and Sv.
Basic radiation dose limit	mrem/yr	25	1E-34–1E+34 **(N)**	NA	This is the annual radiation dose limit in mrem/yr used to derive all site-specific guidelines.
Exposure duration (for risk)	yr	30	1–1,000	B	The exposure duration is the span of time, in years, an individual is expected to spend at the exposure location.

[a] The default values listed in this table are the default values in the RESRAD-OFFSITE V4.0.
[b] Code-accepted values are not provided for element- or nuclide-specific parameters.
[c] Numerical range is the range defined in a program file to prevent code crashes.
[d] P = physical, B = behavioral, M = metabolic; when more than one type is listed, the first is primary and the next is secondary.
[e] “–” indicates that the parameter is dimensionless.
[f] NA = not applicable.

Table A-5 Parameters and Their Default Values Used in RESRAD-OFFSITE V4.0 (cont.)

Input Screen Title and Parameter Name	Units	Default Value[a]	Code-Accepted Values[b] Physical or Numerical[c] (N) Range	Type[d]	Description
Preliminary Inputs (cont.)					
Number of unsaturated zones	–	1	0–5 **(N)**	P	Number of unsaturated zones. An unsaturated zone is defined as a horizontal uncontaminated layer located between the contaminated zone and the aquifer.
Submerged fraction of primary contamination	–	0	0–1	P	The code can model submerged contamination. This is the fraction of the primary contamination that is submerged.
Conceptualization of primary contamination	–	RESRAD-ONSITE Exponential Release Model	RESRAD-ONSITE Exponential Release Model /Specify initial activity based on mass of entire primary contamination/Specify initial activity based on mass of contaminated medium/Model diffusive transport out of contaminated medium	P	This is the choice for conceptualization of primary contamination. Multiple options are available to model the transfer of radionuclides from the contaminated medium to the soil moisture. If “Specify initial activity based on mass of primary contamination” or “contaminated medium” option is selected, multiple forms of contaminated media can be modeled.
Default release mechanism	–	Equilibrium desorption	Equilibrium desorption/ Equilibrium solubility/First order rate controlled	P	It is not displayed for the default conceptualization “RESRAD-ONSITE Exponential Release Model”. For other conceptualizations, default is “Equilibrium desorption”.
Maximum number of iterations for solubility release	–	5	1–10		This is the number of iterations for the solubility release mechanism selected.
First time at which release begins	yr	0	0–100,000	P	This is the time at which release properties begin.
Number of times at which the release properties change	–	1	1–9	P	This is the number of times at which release properties change.
Source					
Nuclide concentration	–	100 pCi/g	0–1E+34 **(N)**	P	The radionuclide concentration in the contaminated zone. The contaminated zone is treated as a uniformly contaminated area with a single radionuclide concentration at every point.

[a] The default values listed in this table are the default values in the RESRAD-OFFSITE V4.0.
[b] Code-accepted values are not provided for element- or nuclide-specific parameters.
[c] Numerical range is the range defined in a program file to prevent code crashes.
[d] P = physical, B = behavioral, M = metabolic; when more than one type is listed, the first is primary and the next is secondary.
[e] “–” indicates that the parameter is dimensionless.
[f] NA = not applicable.

Table A-5 Parameters and Their Default Values Used in RESRAD-OFFSITE V4.0 (cont.)

Input Screen Title and Parameter Name	Units	Default Value[a]	Code-Accepted Values[b] Physical or Numerical[c] (N) Range	Type[d]	Description
Source Release					
Release to groundwater					
Transfer mechanism		Equilibrium desorption	Equilibrium desorption/ Equilibrium solubility/First order rate controlled	P	This is the transfer mechanism selected, which will depend on the choice of conceptualization. Nothing is shown with the initial default conceptualization of "RESRAD-ONSITE" exponential release methodology. "Equilibrium desorption" is the initial default for the other three conceptualizations unless the user makes another choice or checks the "model multiple forms of contaminated media" box in the conceptualization.
Time at which release begins or changes	yr	0	0–100,000	P	This is the time when release begins or changes.
Cumulative fraction of radionuclide bearing material that is releasable		1	0–1	P	This is the cumulative fraction of radionuclide bearing material that is releasable at times when release begins or changes.
Incremental fraction of radionuclide bearing material that becomes releasable		Stepwise at time	Linearly over time/stepwise at time	P	This is how the release occurs. For the first release time, the default is stepwise at time and the default for all subsequent times is linearly over time.
Distribution coefficient in primary contamination	cm^3/g	Nuclide-dependent	0–1E+34 **(N)**	P	This is the ratio of the concentration of the contaminant in adsorbed phase in primary contamination to the concentration of the contaminant in the aqueous phase of primary contamination.
Distribution coefficient in the contaminated medium	cm^3/g	Nuclide-dependent	0–1E+34 **(N)**	P	This is the ratio of the concentration of the contaminant in adsorbed phase in contaminated medium to the concentration of the contaminant in the aqueous phase of the contaminated medium.
Soluble concentration of an isotope	g atomic weight/L	0	0–1E+34**(N)**	P	This is the soluble concentration of an isotope. By default solubility limit is not used.
Soluble concentration of an isotope changes		Stepwise at time	Linearly over time/stepwise at time	P	This is how the soluble concentration changes. For the first release time, the default is stepwise at time and the default for all subsequent times it is linearly over time.

[a] The default values listed in this table are the default values in the RESRAD-OFFSITE V4.0.
[b] Code-accepted values are not provided for element- or nuclide-specific parameters.
[c] Numerical range is the range defined in a program file to prevent code crashes.
[d] P = physical, B = behavioral, M = metabolic; when more than one type is listed, the first is primary and the next is secondary.
[e] "–" indicates that the parameter is dimensionless.
[f] NA = not applicable.

Table A-5 Parameters and Their Default Values Used in RESRAD-OFFSITE V4.0 (cont.)

Input Screen Title and Parameter Name	Units	Default Value[a]	Code-Accepted Values[b] Physical or Numerical[c] (N) Range	Type[d]	Description
Source Release (cont.)					
Leach rate	1/yr	0	0–1E+34 **(N)**	P	This is the soluble concentration of an isotope. By default leach rate is not used.
Leach rate of an isotope changes		Stepwise at time	Linearly over time/stepwise at time	P	This is how the soluble concentration changes. For the first release time default is stepwise at time and the default for all subsequent times it is linearly over time.
Diffusion coefficient in the contaminated medium	m^2/yr	0	0–1E+34 **(N)**	P	This is the diffusion coefficient of an isotope in a contaminated medium. By default the diffusion model is not used.
Release from surface layer					
Radionuclide becomes available for release		In the same manner as for release to groundwater	In the same manner as for release to groundwater/ Beginning at time zero	P	This is how the radionuclides become releasable from the surface layer.
Distribution Coefficients					
Contaminated zone	cm^3/g	Nuclide-dependent	0–1E+34 **(N)**	P	This is the ratio of the concentration of the contaminant in adsorbed phase in soil to the concentration of the contaminant in the aqueous phase of soil, in cm^3/g.
Unsaturated zone	cm^3/g	Nuclide-dependent	0–1E+34 **(N)**	P	
Saturated zone	cm^3/g	Nuclide-dependent	0–1E+34**(N)**	P	
Suspended sediment in surface water body	cm^3/g	Nuclide-dependent	0–1E+34 **(N)**	P	
Bottom sediment in surface water body	cm^3/g	Nuclide-dependent	0–1E+34 **(N)**	P	
Fruit, grain, nonleafy fields	cm^3/g	Nuclide-dependent	0–1E+34 **(N)**	P	
Leafy vegetable fields	cm^3/g	Nuclide-dependent	0–1E+34 **(N)**	P	
Pasture, silage growing areas	cm^3/g	Nuclide-dependent	0–1E+34 **(N)**	P	
Livestock feed grain fields	cm^3/g	Nuclide-dependent	0–1E+34 **(N)**	P	
Offsite dwelling site	cm^3/g	Nuclide-dependent	0–1E+34 **(N)**	P	

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[b] Code-accepted values are not provided for element- or nuclide-specific parameters.
[c] Numerical range is the range defined in a program file to prevent code crashes.
[d] P = physical, B = behavioral, M = metabolic; when more than one type is listed, the first is primary and the next is secondary.
[e] "–" indicates that the parameter is dimensionless.
[f] NA = not applicable.

Table A-5 Parameters and Their Default Values Used in RESRAD-OFFSITE V4.0 (cont.)

Input Screen Title and Parameter Name	Units	Default Value[a]	Code-Accepted Values[b] Physical or Numerical[c] (N) Range	Type[d]	Description
Deposition Velocities					
Atmospheric transport					
Deposition velocity of respirable particulates	m/s	0.001 0.01 (Cl, I) 0 (Xe)	0–1E+34 **(N)**	P	For nuclides that are transported by contaminated dust, it is the settling velocity of dust particulates that are of respirable size that will be deposited in the lung.
Deposition velocity of all particulates	m/s	0.001 0.01 (Cl, I) 0 (Xe)	0–1E+34 **(N)**	P	For nuclides that are transported by contaminated dust, it is the settling velocity of dust particle that are representative of all particulates.
Transfer Factors					
Fruit, grain, nonleafy vegetables transfer factor	–	Element-dependent	0–1E+34 **(N)**	P	The soil-to-plant transfer factor is the ratio of radionuclide concentration in edible portions of the plant at harvest time to the dry soil radionuclide concentration.
Leafy vegetables transfer factor	–	Element-dependent	0–1E+34 **(N)**	P	
Pasture and silage transfer factor	–	Element-dependent	0–1E+34 **(N)**	P	
Livestock feed grain transfer factor	–	Element-dependent	0–1E+34 **(N)**	P	
Meat transfer factor	–	Element-dependent	0–1E+34 **(N)**	P	The meat/livestock-intake transfer factor is the ratio of radionuclide concentration in beef to the daily intake of the same radionuclide in livestock feed or water.
Milk transfer factor	–	Element-dependent	0–1E+34 **(N)**	P	The milk/livestock-intake transfer factor is the ratio of radionuclide concentration in milk to the daily intake of the same radionuclide in livestock feed or water.
Bioaccumulation factor for fish	–	Element-dependent	0–1E+34 **(N)**	P	The bioaccumulation factor is the ratio of radionuclide concentration in aquatic food to the concentration of the same radionuclide in water.
Bioaccumulation factor for Crustacea and mollusks	–	Element-dependent	0–1E+34 **(N)**	P	The bioaccumulation factor is the ratio of radionuclide concentration in aquatic food to the concentration of the same radionuclide in water.
Reporting Times					
Times at which output is reported	yr	1, 3, 6, 12, 30, 75, 175, 420, 970	0–1E+5	P	These are the times in years following the radiological survey for which tabular values for single-radionuclide soil guidelines and mixture sums are reported in the text output file. (The code calculates dose at time zero and up to nine user-specified times)

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Table A-5 Parameters and Their Default Values Used in RESRAD-OFFSITE V4.0 (cont.)

Input Screen Title and Parameter Name	Units	Default Value[a]	Code-Accepted Values[b] Physical or Numerical[c] (N) Range	Type[d]	Description
Storage Times					
Storage time for surface water	d	1	0–1E+34 **(N)**	B	The storage times are used to calculate radioactive ingrowth and decay adjustment factors for food and feed due to storage. The code has values for fruits, nonleafy vegetables, and grain; leafy vegetables; pasture and silage; milk; well and surface water; livestock feed grain; meat; fish; and Crustacea and mollusks.
Storage time for well water	d	1	0–1E+34 **(N)**	B	
Storage time for fruits, grain, and nonleafy vegetables	d	14	0–1E+34**(N)**	B	
Storage time for leafy vegetables	d	1	0–1E+34 **(N)**	B	
Storage time for pasture and silage	d	1	0–1E+34 **(N)**	B	
Storage time for livestock feed grain	d	5	0–1E+34 **(N)**	B	
Storage time for meat	d	20	0–1E+34 **(N)**	B	
Storage time for milk	d	1	0–1E+34 **(N)**	B	
Storage time for fish	d	7	0–1E+34 **(N)**	B	
Storage time for Crustacea and mollusks	d	7	0–1E+34 **(N)**	B	
Site Layout					
Bearing of X axis	degrees	90	0–360 **(N)**	P	It is the clockwise angle from the north.
X dimension of primary contamination	m	100	-80,000 – +80,000	P	The primary contamination is modeled as a rectangle for atmospheric release and transport calculations. The lengths of the sides of the rectangle are used to define the rectangular region for the atmospheric transport calculations. The area is obtained as the product of these two perpendicular dimensions. The two sides of the rectangle that meet at the lower left corner serve as the axes of the coordinate system that is used to define the locations of the other receptor areas.
Y dimension of primary contamination	m	100	-80,000 – +80,000	P	See above.

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[f] NA = not applicable.

Table A-5 Parameters and Their Default Values Used in RESRAD-OFFSITE V4.0 (cont.)

Input Screen Title and Parameter Name	Units	Default Value[a]	Code-Accepted Values[b] Physical or Numerical[c] (N) Range	Type[d]	Description
Site Layout (cont.)					
Smaller X coordinate of the fruit, grain, nonleafy vegetables plot	m	34.375	-80,000 – +80,000	P	The fruit, grain and nonleafy vegetable plot, the leafy vegetable plot, the pasture and silage growing area, the livestock feed grain fields, and the dwelling site are all approximated by rectangular shapes in the atmospheric transport model. The sides of these rectangles must be parallel to the sides of the primary contamination. The location and size of the rectangular areas are specified by the coordinates of two opposite corners. The coordinates are specified with respect to a system of Cartesian axes on the left and lower sides of the primary contamination. The area is obtained as the product of these two perpendicular dimensions. The size and location of these receptor areas can also be specified in the map interface.
Larger X coordinate of the fruit, grain, nonleafy vegetables plot	m	65.625	-80,000 – +80,000	P	See above.
Smaller Y coordinate of the fruit, grain, nonleafy vegetables plot	m	234	-80,000 – +80,000	P	See above.
Larger Y coordinate of the fruit, grain, nonleafy vegetables plot	m	266	-80,000 – +80,000	P	See above.
Smaller X coordinate of the leafy vegetables plot	m	34.375	-80,000 – +80,000	P	See above.
Larger X coordinate of the leafy vegetables plot	m	65.625	-80,000 – +80,000	P	See above.
Smaller Y coordinate of the leafy vegetables plot	m	268	-80,000 – +80,000	P	See above.

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[c] Numerical range is the range defined in a program file to prevent code crashes.
[d] P = physical, B = behavioral, M = metabolic; when more than one type is listed, the first is primary and the next is secondary.
[e] "–" indicates that the parameter is dimensionless.
[f] NA = not applicable.

Table A-5 Parameters and Their Default Values Used in RESRAD-OFFSITE V4.0 (cont.)

Input Screen Title and Parameter Name	Units	Default Value[a]	Code-Accepted Values[b] Physical or Numerical[c] (N) Range	Type[d]	Description
Site Layout (cont.)					
Larger Y coordinate of the leafy vegetables plot	m	300	-80,000 – +80,000	P	See above.
Smaller X coordinate of the pasture, silage growing area	m	0	-80,000 – +80,000	P	See above.
Larger X coordinate of the pasture, silage growing area	m	100	-80,000 – +80,000	P	See above.
Smaller Y coordinate of the pasture, silage growing area	m	450	-80,000 – +80,000	P	See above.
Larger Y coordinate of the pasture, silage growing area	m	550	-80,000 – +80,000	P	See above.
Smaller X coordinate of the grain fields	m	0	-80,000 – +80,000	P	See above.
Larger X coordinate of the grain fields	m	100	-80,000 – +80,000	P	See above.
Smaller Y coordinate of the grain fields	m	300	-80,000 – +80,000	P	See above.
Larger Y coordinate of the grain fields	m	400	-80,000 – +80,000	P	See above.
Smaller X coordinate of the dwelling site	m	34.375	-80,000 – +80,000	P	See above.
Larger X coordinate of the dwelling site	m	65.625	-80,000 – +80,000	P	See above.
Smaller Y coordinate of the dwelling site	m	134	-80,000 – +80,000	P	See above.
Larger Y coordinate of the dwelling site	m	166	-80,000 – +80,000	P	See above.

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[c] Numerical range is the range defined in a program file to prevent code crashes.
[d] P = physical, B = behavioral, M = metabolic; when more than one type is listed, the first is primary and the next is secondary.
[e] "–" indicates that the parameter is dimensionless.
[f] NA = not applicable.

Table A-5 Parameters and Their Default Values Used in RESRAD-OFFSITE V4.0 (cont.)

Input Screen Title and Parameter Name	Units	Default Value[a]	Code-Accepted Values[b] Physical or Numerical[c] (N) Range	Type[d]	Description
Site Layout (cont.)					
Smaller X coordinate of the surface water body	m	-100	-80,000 – +80,000	P	See above.
Larger X coordinate of the surface water body	m	200	-80,000 – +80,000	P	See above.
Smaller Y coordinate of the surface water body	m	550	-80,000 – +80,000	P	See above.
Larger Y coordinate of the surface water body	m	850	-80,000 – +80,000	P	See above.
Physical and Hydrological					
Precipitation	m/yr	1	0–10	P	The average volume of water in the form of rain, snow, hail, or sleet that falls at the site per unit of area per unit of time. It is used in a number of calculations, including radionuclide leaching from the contaminated zone and accumulation of contaminants in the agricultural fields and pastures. Site-specific data should be used.
Wind speed	m/s	0.89	1E-4–20	P	It is the overall average of the wind speed measured near the ground, in a one-year period. It is used to compute the onsite contaminant concentration in airborne dust and the atmospheric release rate.
Primary Contamination					
Area of primary contamination	m^2	10,000	Calculated	P	Total area of the site that is homogeneously contaminated. This is not user input, but is calculated by the code from the X and Y dimension of the primary contamination.
Length of contamination parallel to aquifer flow	m	100	1E-4–1E+6	P	The distance between two parallel lines perpendicular to the direction of aquifer flow, one at the upgradient edge of the contaminated zone and the other at the downgradient edge of the contaminated zone.

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[b] Code-accepted values are not provided for element- or nuclide-specific parameters.
[c] Numerical range is the range defined in a program file to prevent code crashes.
[d] P = physical, B = behavioral, M = metabolic; when more than one type is listed, the first is primary and the next is secondary.
[e] "–" indicates that the parameter is dimensionless.
[f] NA = not applicable.

Table A-5 Parameters and Their Default Values Used in RESRAD-OFFSITE V4.0 (cont.)

Input Screen Title and Parameter Name	Units	Default Value[a]	Code-Accepted Values[b] Physical or Numerical[c] (N) Range	Type[d]	Description
Primary Contamination (cont.)					
Depth of soil mixing layer	m	0.15	0–1	P, B	The thickness of surface soil that may be assumed to be mixed uniformly from time to time due to anthropogenic or physical processes. It is used to calculate the depth factor for the onsite components of dust inhalation and soil ingestion pathways and for computing the release to the atmosphere. The depth factor is the fraction of resuspendable soil particles at the ground surface that are contaminated. It is calculated by assuming that mixing of the soil will occur within a layer of thickness (depth of mixing layer) at the surface.
Mass loading of all particulates	g/m^3	0.0001	0–2		The average mass of all particulates in a unit volume of air above the primary contamination.
Deposition velocity of all particulates (to compute atmospheric release)	m/s	0.001	0–0.01	P	This is the average velocity with which dust settles onto the contaminated zone. It is used to calculate the release to the atmosphere.
Respirable particulates as a fraction of total particulates		1	0–1	P	This is the fraction of total particulates that is respirable.
Deposition velocity of respirable particulates (to compute atmospheric release)	m/s	0.001	0–0.01	P	This is the average velocity with which respirable dust settles onto the contaminated zone. It is used to calculate the release to the atmosphere.
Irrigation applied per year	m/yr	0.2	0–10	B	This is the average annual irrigation rate, in meters/year, applied to the region of primary contamination. It is the amount of irrigation water that is applied over a period of one year, and is not the actual rate of irrigation applied during the growing period. It is one of the parameters used to calculate radionuclide leaching from the contaminated zone. Site-specific data should be used.

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[b] Code-accepted values are not provided for element- or nuclide-specific parameters.
[c] Numerical range is the range defined in a program file to prevent code crashes.
[d] P = physical, B = behavioral, M = metabolic; when more than one type is listed, the first is primary and the next is secondary.
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[f] NA = not applicable.

Table A-5 Parameters and Their Default Values Used in RESRAD-OFFSITE V4.0 (cont.)

Input Screen Title and Parameter Name	Units	Default Value[a]	Code-Accepted Values[b] Physical or Numerical[c] (N) Range	Type[d]	Description
Primary Contamination (cont.)					
Evapotranspiration coefficient	–	0.5	0–0.999	P	This is the fraction of precipitation and irrigation water that penetrates the topsoil that is lost to the atmosphere by evaporation and by transpiration by the vegetation. The evapotranspiration coefficient is one of a number of parameters used to calculate radionuclide leaching from the contaminated zone.
Runoff coefficient	–	0.2	0–1	P	The fraction of the average annual precipitation that does not penetrate the top soil, but leaves the area of concern as surface runoff. The runoff coefficient is one of a number of parameters used to calculate radionuclide leaching from the contaminated zone.
Rainfall and runoff factor	–	160	0–1,000	P	This is also known as the rainfall erosivity factor; it is a measure of the energy of the rainfall. The value entered is used to compute the erosion rate at all locations.
Slope-length/steepness factor	–	0.4	0–10	P	This factor accounts for the effect of the profile of the terrain (the slope of the land and the length of the slope) on the erosion rate.
Cover and management factor	–	0.003	0 –1	B, P	This factor accounts for the effects of vegetation, mulching, etc., on the erosion rate.
Support practice factor	–	1	0–1	B, P	This factor accounts for conservation practices such as terracing, etc., on the erosion rate.
Fraction of primary contamination that is submerged	–	0	0–1	P	This is the fraction of primary contamination that is submerged.
Contaminated zone					
Thickness of contaminated zone	m	2	1E-5–1,000	P	This is the distance between the uppermost and lowermost soil samples that have radionuclide concentrations clearly above background.
Total porosity of contaminated zone	–	0.4	1E-5–1	P	It is the ratio of the pore volume to the total volume of the contaminated zone.
Dry bulk density of contaminated zone	g/cm^3	1.5	1E-3–22.5	P	Bulk density of the contaminated zone.

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[d] P = physical, B = behavioral, M = metabolic; when more than one type is listed, the first is primary and the next is secondary.
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[f] NA = not applicable.

Table A-5 Parameters and Their Default Values Used in RESRAD-OFFSITE V4.0 (cont.)

Input Screen Title and Parameter Name	Units	Default Value[a]	Code-Accepted Values[b] Physical or Numerical[c] (N) Range	Type[d]	Description
Primary Contamination (cont.)					
Contaminated zone					
Soil erodibility factor of contaminated zone	tons/acre	0.4	0–0.5	P	This quantifies the susceptibility of the soil to erosion.
Effective porosity of contaminated zone	–	0.4	1E-5–1	P	The volume fraction of soil through which water flows.
Field capacity of contaminated zone	–	0.3	1E-5–1	P	It is the volumetric moisture content of soil at which (free) gravity drainage ceases. This is the amount of moisture that will be retained in a column of soil against the force of gravity. The field capacity is one of several hydrogeological parameters used to calculate water transport through the unsaturated part of the soil.
Soil b parameter of contaminated zone	–	5.3	0–15	P	It is an empirical and dimensionless parameter that is used to evaluate the saturation ratio (or the volumetric water saturation) of the soil according to a soil characteristic function called the conductivity function.
Hydraulic conductivity of contaminated zone	m/yr	10	1E-3–1E+10	P	It is the measure of the soil's ability to transmit water when subjected to a hydraulic gradient. The hydraulic conductivity depends on the soil grain size, the structure of the soil matrix, the type of soil fluid, and the relative amount of soil fluid (saturation) present in the soil matrix.
Longitudinal dispersivity	m	0.05	0–15	P	The ratio between the longitudinal dispersion coefficient and the pore water velocity.
Clean cover					
Thickness of clean cover	m	0	0–100	P	Distance from the ground surface to the contaminated zone.
Total porosity of clean cover	–	0.4	1E-5–1	P	This is the volume fraction of soil that is occupied by liquid and gaseous phases. The total porosity is one of several hydrogeological parameters used to calculate water transport times.
Dry bulk density of clean cover	g/cm^3	1.5	1E-3–22.5	P	Bulk density of the cover material.
Soil erodibility factor of clean cover	tons/acre	0.4	0–0.5	P	See "Contaminated zone soil erodibility factor" parameter.

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Table A-5 Parameters and Their Default Values Used in RESRAD-OFFSITE V4.0 (cont.)

Input Screen Title and Parameter Name	Units	Default Value[a]	Code-Accepted Values[b] Physical or Numerical[c] (N) Range	Type[d]	Description
Primary Contamination (cont.)					
Clean cover					
Volumetric water content of clean cover	–	0.05	0–1	P	This is the volumetric water content in a porous medium that represents a fraction of the total volume of porous medium that is occupied by the water. The value should be less than the total porosity of the medium.
Contaminated Medium					
Total mass of contaminated medium	kg	0	0–1E+10	P	This input for the total mass of the contaminated medium is displayed when the user chooses to conceptualize the primary contamination as consisting of a contaminated medium within initially clean soil.
Total volume of contaminated medium	m^3	0	0–1E+10	P	This input for the total volume of the contaminated medium is displayed when the user chooses to conceptualize the primary contamination as consisting of a contaminated medium within initially clean soil.
Volumetric water content of contaminated medium		0	0–1	P	This input for the volumetric water content of the contaminated medium is displayed when the user chooses to model the diffusive transport of the radionuclides on the contaminated medium.
Length of a representative fragment of the contaminated medium	m	0	0–10	P	This input for the length of a representative fragment of the contaminated medium is displayed when the user chooses to model the diffusive transport of the radionuclides on the contaminated medium.
Width of a representative fragment of the contaminated medium	m	0	0–10	P	This input for the width of a representative fragment of the contaminated medium is displayed when the user chooses to model the diffusive transport of the radionuclides on the contaminated medium.
Depth of a representative fragment of the contaminated medium	m	0	0–10	P	This input for the depth of a representative fragment of the contaminated medium is displayed when the user chooses to model the diffusive transport of the radionuclides on the contaminated medium.
Sediment Delivery Ratio - *Fate of Material Eroded from the Primary Contamination by Runoff*					
Fraction of eroded radionuclides deposited at dwelling site	–	0	0–1	P	This is the fraction of the contaminated soil that was eroded from the area of primary contamination that reaches the dwelling site.

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Table A-5 Parameters and Their Default Values Used in RESRAD-OFFSITE V4.0 (cont.)

Input Screen Title and Parameter Name	Units	Default Value[a]	Code-Accepted Values[b] Physical or Numerical[c] (N) Range	Type[d]	Description
Sediment Delivery Ratio *- Fate of Material Eroded from the Primary Contamination by Runoff (cont.)*					
Fraction of eroded radionuclides deposited in the nonleafy vegetable plot	–	0	0–1	P	This is the fraction of the contaminated soil that was eroded from the area of primary contamination that reaches the nonleafy vegetable plot.
Fraction of eroded radionuclides deposited in the feed grain plot	–	0	0–1	P	This is the fraction of the contaminated soil that was eroded from the area of primary contamination that reaches the feed grain plot.
Fraction of eroded radionuclides deposited in the surface water body	–	1	0–1	P	This is the fraction of the contaminated soil that was eroded from the area of primary contamination that reaches the surface water body.
Agriculture Areas					
Fruit, grain, and nonleafy vegetables field					
Area for fruit, grain, and nonleafy vegetables field	m^2	1,000	Calculated	B	Area for growing fruit, grain, and nonleafy vegetables. This is not user input, but is calculated by the code from the X and Y coordinates of the fruit, grain, and nonleafy vegetable field.
Fraction of area directly over primary contamination for fruit, grain, and nonleafy vegetables field	–	0	0–1	B, P	Fraction of the growing area directly over primary contamination.
Irrigation applied per year for fruit, grain, and nonleafy vegetables field	m/yr	0.2	0–10	B	See “Primary contamination area irrigation” parameter.
Evapotranspiration coefficient for fruit, grain, and nonleafy vegetables field	–	0.5	0–0.999	P	See “Primary contamination area evapotranspiration coefficient” parameter.
Runoff coefficient for fruit, grain, and nonleafy vegetables field	–	0.2	0–1	P	See “Primary contamination area runoff coefficient” parameter.

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Table A-5 Parameters and Their Default Values Used in RESRAD-OFFSITE V4.0 (cont.)

Input Screen Title and Parameter Name	Units	Default Value[a]	Code-Accepted Values[b] Physical or Numerical[c] (N) Range	Type[d]	Description
Agriculture Areas (cont.)					
Fruit, grain, and nonleafy vegetables field					
Depth of soil mixing layer or plow layer for fruit, grain, and nonleafy vegetables field	m	0.15	0–1	P, B	See "Primary contamination area depth of soil mixing layer" parameter.
Volumetric water content for fruit, grain, and nonleafy vegetables field	–	0.3	1E-5–1	P	This is the fraction of the total volume of porous medium that is occupied by water. The value should not exceed the total porosity of the medium.
Dry bulk density of soil for fruit, grain, and nonleafy vegetables field	g/cm^3	1.5	1E-3–22.5	P	See "Contaminated zone dry bulk density" parameter.
Soil erodibility factor for fruit, grain, and nonleafy vegetables field	tons/acre	0.4	0–0.5	P	See "Contaminated zone soil erodibility factor" parameter.
Slope-length/steepness factor for fruit, grain, and nonleafy vegetables field	–	0.4	0–10	P	See "Primary contamination area slope-length/steepness factor" parameter.
Cover and management factor for fruit, grain, and nonleafy vegetables field	–	0.003	0–1	B, P	See "Primary contamination area cover and management factor" parameter.
Support practice factor for fruit, grain, and nonleafy vegetables field	–	1	0–1	B, P	See "Primary contamination area support practice factor" parameter.
Leafy vegetable field					
Area for leafy vegetable field	m^2	1,000	Calculated	B	Area for growing leafy vegetables. This is not user input, but is calculated by the code from the X and Y coordinates of the leafy vegetable field.

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[b] Code-accepted values are not provided for element- or nuclide-specific parameters.
[c] Numerical range is the range defined in a program file to prevent code crashes.
[d] P = physical, B = behavioral, M = metabolic; when more than one type is listed, the first is primary and the next is secondary.
[e] "–" indicates that the parameter is dimensionless.
[f] NA = not applicable.

Table A-5 Parameters and Their Default Values Used in RESRAD-OFFSITE V4.0 (cont.)

Input Screen Title and Parameter Name	Units	Default Value[a]	Code-Accepted Values[b] Physical or Numerical[c] (N) Range	Type[d]	Description
Agriculture Areas (cont.)					
Leafy vegetable field					
Fraction of area directly over primary contamination for leafy vegetable field	–	0	0 – 1	B, P	Fraction of the growing area directly over primary contamination.
Irrigation applied per year for leafy vegetable field	m/yr	0.2	0 – 10	B	See “Primary contamination area irrigation” parameter.
Evapotrans-piration coefficient for leafy vegetable field	–	0.5	0 – 0.999	P	See “Primary contamination area evapotranspiration coefficient” parameter.
Runoff coefficient for leafy vegetable field	–	0.2	0 – 1	P	See “Primary contamination area runoff coefficient” parameter.
Depth of soil mixing layer or plow layer for leafy vegetables field	m	0.15	0–1	P, B	See “Primary contamination area depth of soil mixing layer” parameter.
Volumetric water content for leafy vegetables field	–	0.3	1E-5–1	P	See “Fruit, grain, and nonleafy field volumetric water content” parameter.
Dry bulk density of soil for leafy vegetables field	g/cm^3	1.5	1E-3–22.5	P	See “Contaminated zone dry bulk density” parameter.
Soil erodibility factor for leafy vegetables field	tons/acre	0.4	0–0.5	P	See “Contaminated zone soil erodibility factor” parameter.
Slope-length/steepness factor for leafy vegetables field	–	0.4	0–10	P	See “Primary contamination area slope-length/steepness factor” parameter.
Cover and management factor for leafy vegetables field	–	0.003	0–1	B, P	See “Primary contamination area cover and management factor” parameter.
Support practice factor for leafy vegetables field	–	1	0–1	B, P	See “Primary contamination area support practice factor” parameter.

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[b] Code-accepted values are not provided for element- or nuclide-specific parameters.
[c] Numerical range is the range defined in a program file to prevent code crashes.
[d] P = physical, B = behavioral, M = metabolic; when more than one type is listed, the first is primary and the next is secondary.
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Table A-5 Parameters and Their Default Values Used in RESRAD-OFFSITE V4.0 (cont.)

Input Screen Title and Parameter Name	Units	Default Value[a]	Code-Accepted Values[b] Physical or Numerical[c] (N) Range	Type[d]	Description
Livestock Feed Growing Areas					
Pasture and silage field					
Area for pasture and silage field	m^2	10,000	Calculated	B	Area for growing pasture and silage. This is not user input, but is calculated by the code from the X and Y coordinates of the pasture and silage field.
Fraction of area directly over primary contamination for pasture and silage field	–	0	0–1	B, P	Fraction of the growing area directly over primary contamination.
Irrigation applied per year for pasture and silage field	m/yr	0.2	0 – 10	B	See “Primary contamination area irrigation” parameter.
Evapotrans-piration coefficient for pasture and silage field	–	0.5	0–0.999	P	See “Primary contamination area evapotranspiration coefficient” parameter.
Runoff coefficient for pasture and silage field	–	0.2	0–1	P	See “Primary contamination area runoff coefficient” parameter.
Depth of soil mixing layer or plow layer for pasture and silage field	m	0.15	0–1	P, B	See “Primary contamination area depth of soil mixing layer” parameter.
Volumetric water content for pasture and silage field	–	0.3	1E-5–1	P	See “Fruit, grain, and nonleafy field volumetric water content” parameter.
Dry bulk density of soil for pasture and silage field	g/cm^3	1.5	1E-3–22.5	P	See “Contaminated zone dry bulk density” parameter.
Soil erodibility factor for pasture and silage field	tons/acre	0.4	0–0.5	P	See “Contaminated zone soil erodibility factor” parameter.
Slope-length/steepness factor for pasture and silage field	–	0.4	0–10	P	See “Primary contamination area slope-length/steepness factor” parameter.
Cover and management factor for pasture and silage field	–	0.003	0–1	B, P	See “Primary contamination area cover and management factor” parameter.

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[b] Code-accepted values are not provided for element- or nuclide-specific parameters.
[c] Numerical range is the range defined in a program file to prevent code crashes.
[d] P = physical, B = behavioral, M = metabolic; when more than one type is listed, the first is primary and the next is secondary.
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[f] NA = not applicable.

Table A-5 Parameters and Their Default Values Used in RESRAD-OFFSITE V4.0 (cont.)

Input Screen Title and Parameter Name	Units	Default Value[a]	Code-Accepted Values[b] Physical or Numerical[c] (N) Range	Type[d]	Description
Livestock Feed Growing Areas					
Pasture and silage field					
Support practice factor for pasture and silage field	–	1	0–1	B, P	See “Primary contamination area support practice factor” parameter.
Grain field					
Area for grain field	m^2	10,000	Calculated	B	Area for growing grain. This is not user input, but is calculated by the code from the X and Y coordinates of the grain field.
Fraction of area directly over primary contamination for grain field	–	0	0–1	B, P	Fraction of the growing area directly over primary contamination.
Irrigation applied per year for grain field	m/yr	0.2	0–10	B	See “Primary contamination area irrigation” parameter.
Evapotrans-piration coefficient for grain field	–	0.5	0–0.999	P	See “Primary contamination area evapotranspiration coefficient” parameter.
Runoff coefficient for grain field	–	0.2	0–1	P	See “Primary contamination area runoff coefficient” parameter.
Depth of soil mixing layer or plow layer for grain field	m	0.15	0–1	P, B	See “Primary contamination area depth of soil mixing layer” parameter.
Volumetric water content for grain field	–	0.3	1E-5–1	P	See “Fruit, grain, and nonleafy field volumetric water content” parameter.
Dry bulk density of soil for grain field	g/cm^3	1.5	1E-3–22.5	P	See “Contaminated zone dry bulk density” parameter.
Soil erodibility factor for grain field	tons/acre	0.4	0–0.5	P	See “Contaminated zone soil erodibility factor” parameter.
Slope-length/steepness factor for grain field	–	0.4	0–10	P	See “Primary contamination area slope-length/steepness factor” parameter.
Cover and management factor for grain field	–	0.003	0–1	B, P	See “Primary contamination area cover and management factor” parameter.
Support practice factor for grain field	–	1	0–1	B, P	See “Primary contamination area support practice factor” parameter.

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[f] NA = not applicable.

Table A-5 Parameters and Their Default Values Used in RESRAD-OFFSITE V4.0 (cont.)

Input Screen Title and Parameter Name	Units	Default Value[a]	Code-Accepted Values[b] Physical or Numerical[c] (N) Range	Type[d]	Description
Offsite Dwelling Area					
Area of offsite dwelling site	m^2	1,000	Calculated	B	Area for offsite dwelling site. This is not user input, but is calculated by the code from the X and Y coordinates of the offsite dwelling site.
Irrigation applied per year to home garden or lawn	m/yr	0.2	0–10	B	See "Primary contamination area irrigation" parameter.
Evapotrans-piration coefficient for dwelling site	–	0.5	0–0.999	P	See "Primary contamination area evapotranspiration coefficient" parameter.
Runoff coefficient for dwelling site	–	0.2	0–1	P	See "Primary contamination area runoff coefficient" parameter.
Depth of soil mixing layer for dwelling site	m	0.15	0–1	P, B	See "Primary contamination area depth of soil mixing layer" parameter.
Volumetric water content for dwelling site	–	0.3	1E-5–1	P	See "Fruit, grain, and nonleafy field volumetric water content" parameter.
Dry bulk density of soil for dwelling site	g/cm^3	1.5	1E-3–22.5	P	See "Contaminated zone dry bulk density" parameter.
Soil erodibility factor for dwelling site	tons/acre	0	0–0.5	P	See "Contaminated zone soil erodibility factor" parameter.
Slope-length/steepness factor for dwelling site	–	0.4	0–10	P	See "Primary contamination area slope-length/steepness factor" parameter.
Cover and management factor for dwelling site	–	0.003	0–1	B, P	See "Primary contamination area cover and management factor" parameter.
Support practice factor for dwelling site	–	1	0–1	B, P	See "Primary contamination area support practice factor" parameter.
Atmospheric Transport					
Release height	m	1	0–100	P	The elevation of primary contamination with respect to the ground level in the vicinity.
Release heat flux	cal/s	0	0 1E+10		The heat energy associated with the contaminant release.
Anemometer height	m	10	0–100	P	This is the height at which the value for wind speed is measured.

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[d] P = physical, B = behavioral, M = metabolic; when more than one type is listed, the first is primary and the next is secondary.
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Table A-5 Parameters and Their Default Values Used in RESRAD-OFFSITE V4.0 (cont.)

Input Screen Title and Parameter Name	Units	Default Value[a]	Code-Accepted Values[b] Physical or Numerical[c] (N) Range	Type[d]	Description
Atmospheric Transport (cont.)					
Ambient temperature	K	285	250–320	P	Ambient temperature used in the calculation of plume rise of escaped material.
AM atmospheric mixing height	m	400	0–3,000	P	This is the annual average morning mixing height. The annual average morning mixing height and annual afternoon mixing height are used to determine the mixing height for different Pasquill stability classes.
PM atmospheric mixing height	m	1,600	0–3,000	P	This is the annual afternoon mixing height.
Dispersion model coefficients	–	Pasquill-Gifford	Briggs rural/urban, Pasquill-Gifford	P	Controls which dispersion coefficients are used for the plume dispersion calculations. Pasquill-Gifford coefficients should be used for releases at or near ground level.
Wind speed terrain	–	Rural	Rural, urban	P	Used to select the wind speed height relationship appropriate for the terrain.
Fruit, grain, nonleafy vegetables plot elevation	m	0	0–100	P	This is the elevation of the fruit, grain, nonleafy vegetables plot relative to primary contamination.
Leafy vegetables plot elevation	m	0	0–100	P	This is the elevation of the leafy vegetables plot relative to primary contamination.
Pasture, silage growing area elevation	m	0	0–100	P	This is the elevation of the pasture, silage growing area relative to primary contamination.
Grain fields elevation	m	0	0–100	P	This is the elevation of the grain fields relative to primary contamination.
Dwelling site elevation	m	0	0–100	P	This is the elevation of the dwelling site relative to primary contamination.
Surface water body elevation	m	0	0–100	P	This is the elevation of the surface water body relative to primary contamination.
Grid spacing for areal integration	m	10	0–500	P	The primary contamination and the offsite receptor areas are assumed to be rectangular in shape when modeling the atmospheric transport. Rather than use a single transport distance from the centers of the source and the receptor, the code provides the option to subdivide the source and receptor areas into smaller squares or rectangles. The transport from each subdivision of the source to each subdivision of the offsite receptor area is computed and summed together to get a better estimate of the atmospheric transport.

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Table A-5 Parameters and Their Default Values Used in RESRAD-OFFSITE V4.0 (cont.)

Input Screen Title and Parameter Name	Units	Default Value[a]	Code-Accepted Values[b] Physical or Numerical[c] (N) Range	Type[d]	Description
Atmospheric Transport (cont.)					
Joint frequency of wind speed and stability class for a 16 sector wind rose	–	S to N	0–1	P	This is the fraction of the time that the atmospheric conditions in a specified sector (compass direction) fall within each wind speed interval and stability class combination. Only one of the 16 sectors is displayed at a time, but the information for all the sectors that are relevant to the scenario are used. S to N is the sector with 0.1, 0.2, and 0.7 respectively for classes D, E, and F in default setting. The code starts off with all the receptor/accumulation locations to the north of the primary contamination and classes D, E and F give a higher dose for a near ground level release as there is less dispersion in these cases.
Wind speed	m/s	0.89, 2.46, 4.47, 6.93, 9.61, 12.52	0.001–20	P	Wind speeds for the joint frequency data.
Water Use					
Consumption by humans					
Quantity of water consumed by an individual	L/yr	510	0–1,000	M, B	This is the total amount of water consumed by an individual; it includes water that is used in the preparation of and consumed with food.
Fraction of water from surface body for consumption by humans	–	0	0–1	B, P	This is the fraction of water consumed by humans that is obtained from the surface water source.
Fraction of water from well for consumption by humans	–	1	0–1	B, P	This is the fraction of water consumed by humans that is obtained from the well.
Number of household individuals consuming and using water	–	4	0–1,000	B	Number of household individuals for calculating water use.

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[b] Code-accepted values are not provided for element- or nuclide-specific parameters.
[c] Numerical range is the range defined in a program file to prevent code crashes.
[d] P = physical, B = behavioral, M = metabolic; when more than one type is listed, the first is primary and the next is secondary.
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[f] NA = not applicable.

Table A-5 Parameters and Their Default Values Used in RESRAD-OFFSITE V4.0 (cont.)

Input Screen Title and Parameter Name	Units	Default Value[a]	Code-Accepted Values[b] Physical or Numerical[c] (N) Range	Type[d]	Description
Water Use (cont.)					
Use indoors of dwelling					
Quantity of water for use indoors of dwelling per individual	L/day	225	0–1,000	M, B	This is the total amount of water used indoors by an individual for bathing, laundry, washing, etc. This quantity is used to estimate the volume of water that needs to be extracted from the well to satisfy the specified needs.
Fraction of water from surface body for use indoors of dwelling	–	0	0–1	B, P	This is the fraction of water used in the dwelling that is obtained from the surface water source. This factor is used in the computation of indoor radon.
Fraction of water from well for use indoors of dwelling	–	1	0–1	B, P	This is the fraction of water used in the dwelling obtained from the well. This factor is used in the computation of indoor radon.
Beef cattle					
Quantity of water for beef cattle	L/day	50	0–500	M, B	This is the total amount of water used by beef cattle. This quantity estimates the volume of water extracted from the well to satisfy the specified needs.
Fraction of water from surface body for beef cattle	–	0	0–1	B, P	This is the fraction of water consumed by beef cattle raised for meat obtained from the surface water source.
Fraction of water from well for beef cattle	–	1	0–1	B, P	This is the fraction of water consumed by beef cattle raised for meat obtained from the well water source.
Number of beef cattle	–	2	0–10	B	Number of beef cattle for calculating water use.
Dairy cows					
Quantity of water for dairy cows	L/day	160	0–1,000	M, B	This is the total amount of water used by dairy cows. This quantity estimates the volume of water extracted from the well to satisfy the specified needs.
Fraction of water from surface body for dairy cows	–	0	0–1	B, P	This is the fraction of water consumed by dairy cows raised for milk obtained from the surface water source.
Fraction of water from well for dairy cows	–	1	0–1	B, P	This is the fraction of water consumed by dairy cows raised for milk obtained from the well water source.
Number of dairy cows	–	2	0–10	B	Number of dairy cows for calculating water use.

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[b] Code-accepted values are not provided for element- or nuclide-specific parameters.
[c] Numerical range is the range defined in a program file to prevent code crashes.
[d] P = physical, B = behavioral, M = metabolic; when more than one type is listed, the first is primary and the next is secondary.
[e] "–" indicates that the parameter is dimensionless.
[f] NA = not applicable.

Table A-5 Parameters and Their Default Values Used in RESRAD-OFFSITE V4.0 (cont.)

Input Screen Title and Parameter Name	Units	Default Value[a]	Code-Accepted Values[b] Physical or Numerical[c] (N) Range	Type[d]	Description
Irrigation Applied Per Year					
Fruit, grain, nonleafy vegetables					
Fraction of water from surface body for fruit, grain, and nonleafy vegetables	–	0	0–1	B, P	This is the fraction of irrigation from the surface water source applied to fruit, grain, and nonleafy vegetable fields.
Fraction of water from well for fruit, grain, and nonleafy vegetables	–	1	0–1	B, P	This is the fraction of irrigation water from the well applied to fruit, grain, and nonleafy vegetable fields.
Leafy vegetables					
Fraction of water from surface body for leafy vegetables	–	0	0–1	B, P	This is the fraction of irrigation from the surface water source applied to leafy vegetable fields.
Fraction of water from well for leafy vegetables	–	1	0–1	B, P	This is the fraction of irrigation water from the well applied to leafy vegetable fields.
Pasture and silage					
Fraction of water from surface body for pasture and silage	–	0	0–1	B, P	This is the fraction of irrigation from the surface water source applied to pasture and silage fields.
Fraction of water from well for pasture and silage	–	1	0–1	B, P	This is the fraction of irrigation water from the well applied to pasture and silage fields.
Livestock feed grain					
Fraction of water from surface body for livestock feed grain	–	0	0–1	B, P	This is the fraction of irrigation from the surface water source applied to livestock feed grain fields.
Fraction of water from well for livestock feed grain	–	1	0–1	B, P	This is the fraction of irrigation water from the well applied to livestock feed grain fields.
Offsite dwelling site					
Fraction of water from surface body for offsite dwelling site	–	0	0–1	B, P	This is the fraction of irrigation from the surface water source applied to offsite dwelling site.

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[b] Code-accepted values are not provided for element- or nuclide-specific parameters.
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[d] P = physical, B = behavioral, M = metabolic; when more than one type is listed, the first is primary and the next is secondary.
[e] "–" indicates that the parameter is dimensionless.
[f] NA = not applicable.

Table A-5 Parameters and Their Default Values Used in RESRAD-OFFSITE V4.0 (cont.)

Input Screen Title and Parameter Name	Units	Default Value[a]	Code-Accepted Values[b] Physical or Numerical[c] (N) Range	Type[d]	Description
Irrigation Applied Per Year (cont.)					
Offsite dwelling site					
Fraction of water from well for offsite dwelling site	–	1	0–1	B, P	This is the fraction of irrigation water from the well applied to offsite dwelling site.
Well pumping rate	m^3/yr	5,100	0–100,000	B, P	This is the total volume of water withdrawn from the well for all purposes. It estimates the dilution that occurs in the well.
Well pumping rate needed to support specified water use	m^3/yr	5,084.17	Calculated	B, P	This is not an input; it is the lower bound to the well pumping rate calculated by the code.
Unsaturated Zone Hydrology					
Number of unsaturated zones set in preliminary inputs form		1			Parameter is from the preliminary inputs form.
Unsaturated zone thickness	m	4	0.01–10,000	P	This is the thickness of the specific unsaturated zone.
Unsaturated zone dry bulk density	g/cm^3	1.5	1E-3–22.5	P	See "Contaminated zone dry bulk density" parameter.
Unsaturated zone total porosity	–	0.4	1E-5–1	P	See "Clean cover total porosity" parameter.
Unsaturated zone effective porosity	–	0.2	1E-5–1	P	The effective porosity of the unsaturated zone is the ratio of the pore volume where water can circulate to the total volume of the unsaturated zone. It is used along with other hydrological parameters to calculate the water transport breakthrough times.
Unsaturated zone field capacity	–	0.3	1E-5–1	P	See "Contaminated zone field capacity" parameter.
Unsaturated zone hydraulic conductivity	m/yr	10	1E-3–1E+6	P	See "Contaminated zone hydraulic conductivity" parameter.
Unsaturated zone soil b parameter	–	5.3	0–15	P	See "Contaminated zone soil b" parameter.
Unsaturated zone longitudinal dispersivity	m	0.1	0–100	P	This is the ratio between the longitudinal dispersion coefficient and pore water velocity. This parameter is dependent on the thickness of the zone.

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[d] P = physical, B = behavioral, M = metabolic; when more than one type is listed, the first is primary and the next is secondary.
[e] "–" indicates that the parameter is dimensionless.
[f] NA = not applicable.

Table A-5 Parameters and Their Default Values Used in RESRAD-OFFSITE V4.0 (cont.)

Input Screen Title and Parameter Name	Units	Default Value[a]	Code-Accepted Values[b] Physical or Numerical[c] (N) Range	Type[d]	Description
Saturated Zone Hydrology					
Thickness of saturated zone	m	100	0–1,000	P	This is the thickness of the saturated zone.
Dry bulk density of saturated zone	g/cm^3	1.5	1E-3–22.5	P	See “Contaminated zone dry bulk density” parameter.
Saturated zone total porosity	–	0.4	1E-5–1	P	See “Clean cover total porosity” parameter.
Saturated zone effective porosity	–	0.2	1E-5–1	P	See “Unsaturated zone effective porosity” parameter.
Saturated zone hydraulic conductivity	m/yr	100	1E-3–1E+10	P	See “Contaminated zone hydraulic conductivity” parameter.
Saturated zone hydraulic gradient to well	–	0.02	1E-10–10	P	This is the slope of the surface of the water table. The hydraulic gradient is one of several hydrogeological parameters used in water transport calculations.
Depth of aquifer contributing to well	m	10	1E-4–1,000	P	The well is assumed to be fully screened from the water table to the specified well screen depth.
Saturated zone longitudinal dispersivity to well	m	3	0 – 1,000	P	See unsaturated zone longitudinal dispersivity parameter.
Saturated zone horizontal lateral dispersivity to well	m	0.4	0–1,000	P	This is the ratio between the horizontal lateral dispersion coefficient and pore water velocity. This parameter is usually about one-tenth to three-tenths of the longitudinal dispersivity.
Saturated zone vertical lateral dispersivity to well	m	0.02	0–1,000	P	This is the ratio between the vertical lateral dispersion coefficient and pore water velocity.
Saturated zone hydraulic gradient to surface water body	–	0.02	1E-10–10	P	This is the slope of the surface of the water table. The hydraulic gradient is one of several hydrogeological parameters used in water transport calculations.
Depth of aquifer contributing to surface water body	m	10	0–1,000	P	This is the depth of the aquifer that flows into the surface water body. If water flows in the opposite direction (from the surface water body into the aquifer) this depth would be zero. This depth calculates the contaminant flux reaching the surface water body by way of the aquifer.
Saturated zone longitudinal dispersivity to surface water body	m	10	0–1,000	P	See “Unsaturated zone longitudinal dispersivity” parameter.

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Table A-5 Parameters and Their Default Values Used in RESRAD-OFFSITE V4.0 (cont.)

Input Screen Title and Parameter Name	Units	Default Value[a]	Code-Accepted Values[b] Physical or Numerical[c] (N) Range	Type[d]	Description
Saturated Zone Hydrology (cont.)					
Saturated zone horizontal lateral dispersivity to surface water body	m	1	0–1,000	P	This is the ratio between the horizontal lateral dispersion coefficient and pore water velocity. This parameter is usually about one-tenth to three-tenths of the longitudinal dispersivity.
Saturated zone vertical lateral dispersivity to surface water body	m	0.06	0–1,000	P	This is the ratio between the vertical lateral dispersion coefficient and pore water velocity.
Groundwater Transport					
Distance in the direction parallel to aquifer flow from downgradient edge of contamination to:					
Well	m	100	-16,000 – +16,000	P, B	This is the distance between two parallel lines that are perpendicular to the direction of aquifer flow, one at the downgradient edge of the contaminated zone and the other at the well.
Surface water	m	450	-16,000 – +16,000	P	This the distance between two parallel lines that are perpendicular to the direction of aquifer flow, one at the downgradient edge of the contaminated zone and the other at the closest point on the surface water body.
Distance in the direction perpendicular to aquifer flow from center of contamination to:					
Well	m	0	-16,000 – +16,000	P, B	This is the distance between two parallel lines that are parallel to the direction of aquifer flow, one through the center of the contaminated zone and the other at the well.
Left edge of surface water body	m	150	-16,000 – +16,000	P	This is the distance between two parallel lines that are parallel to the direction of aquifer flow, one through the center of the contaminated zone and the other at the closest point on the surface water body.
Right edge of surface water body	m	-150	-16,000 – +16,000	P	This the distance between two parallel lines that are parallel to the direction of aquifer flow, one through the center of the contaminated zone and the other at the farthest point on the surface water body.
Convergence criterion (fractional accuracy desired)	–	0.001	0–0.1	P	This is the fractional accuracy desired (convergence criterion) in the Romberg integration used to calculate the contaminant flux or concentration in groundwater.

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[c] Numerical range is the range defined in a program file to prevent code crashes.

[d] P = physical, B = behavioral, M = metabolic; when more than one type is listed, the first is primary and the next is secondary.

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[f] NA = not applicable.

Table A-5 Parameters and Their Default Values Used in RESRAD-OFFSITE V4.0 (cont.)

Input Screen Title and Parameter Name	Units	Default Value[a]	Code-Accepted Values[b] Physical or Numerical[c] (N) Range	Type[d]	Description
Groundwater Transport (cont.)					
Number of subzones (to model dispersion of progeny produced in transit)					
Main subzones in contaminated Medium	–	1	1–1024	NA	The contaminated medium can be subdivided into subzones to improve the predictions for the transport of progeny nuclides.
Main subzones in primary contamination	–	1	1–1024	NA	The primary contamination can be subdivided into subzones to improve the predictions for the transport of progeny nuclides.
Main subzones in submerged primary contamination	–	1	1–1024	NA	The submerged primary contamination can be subdivided into subzones to improve the predictions for the transport of progeny nuclides.
Main subzones in saturated zone	–	1	1–1024	NA	The saturated zone can be subdivided into subzones to improve the predictions for the transport of progeny nuclides.
Main subzones in each partially saturated zone	–	1	1–1024	NA	Each partially saturated zone can be subdivided into subzones to improve the predictions for the transport of progeny nuclides.
Retardation and dispersion treatment					
Nuclide-specific retardation in all subzones, longitudinal dispersion in all but the subzone of transformation	–	Yes	Yes/No	NA	When the layer is subdivided, one must choose which process—longitudinal dispersion or nuclide-specific retardation—will be considered in the subzone in which each atom undergoes a transformation.
Longitudinal dispersion in all subzones, nuclide-specific retardation in all but the subzone of transformation, parent retardation in zone of transformation	–	No	Yes/No	NA	See above.

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[c] Numerical range is the range defined in a program file to prevent code crashes.
[d] P = physical, B = behavioral, M = metabolic; when more than one type is listed, the first is primary and the next is secondary.
[e] "–" indicates that the parameter is dimensionless.
[f] NA = not applicable.

Table A-5 Parameters and Their Default Values Used in RESRAD-OFFSITE V4.0 (cont.)

Input Screen Title and Parameter Name	Units	Default Value[a]	Code-Accepted Values[b] Physical or Numerical[c] (N) Range	Type[d]	Description
Groundwater Transport (cont.)					
Retardation and dispersion treatment					
Longitudinal dispersion in all subzones, nuclide-specific retardation in all but the subzone of transformation, progeny retardation in zone of transformation	–	No	Yes/No	NA	See above.
Surface Water Body					
Volume of surface water body	m^3	150,000	1–1E+34 **(N)**	P	This is the volume of water in a surface water body.
Potential evaporation	m/yr	1	1–10	P	Evaporation rate in the surface water body.
Stream outflow (as a fraction of total outflow)		0.9983	0–1	P	The value can be input or estimated using inflow ratio.
Settling velocity of sediments	cm/s	0.1	0–1	P	The rate at which suspended solids subside and are deposited.
Density of bottom sediment	g/cm^3	1.5	1E-3–22.5	P	See contaminated zone dry bulk density parameter.
Thickness of bottom sediment layer in adsorption/desorption equilibrium of radionuclides with water	m	0.05	0–1	P	The radionuclides in older sediment buried below more recent sediment will not have the opportunity to be in equilibrium with the water in the surface water body. This is the thickness of the top layer of the sediment that is considered for the adsorption-desorption equilibrium of the radionuclide with that in the water.
Sediment from primary contamination delivery ratio	–	1	0–1	P	This is the fraction of the contaminated soil that was eroded from the area of primary contamination that reaches the surface water body.
Number of catchment areas	–	1	0–10	P	This is the number of rectangular areas used to approximate the catchment area that drains in to surface water body.

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[d] P = physical, B = behavioral, M = metabolic; when more than one type is listed, the first is primary and the next is secondary.
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Table A-5 Parameters and Their Default Values Used in RESRAD-OFFSITE V4.0 (cont.)

Input Screen Title and Parameter Name	Units	Default Value[a]	Code-Accepted Values[b] Physical or Numerical[c] (N) Range	Type[d]	Description
Surface Water Body (cont.)					
Characteristics of catchment area					
Smaller X coordinate	m	-1,450	-80,000 – +80,000	P	The catchment area is modeled as a rectangle for release and transport calculations. The sides of this rectangle must be parallel to the sides of the primary contamination. The location and size of these rectangular areas are specified in the code by the coordinates of two opposite corners. The coordinates are specified with respect to a system of Cartesian axes on the left and lower sides of the primary contamination. The area is obtained as the product of these two perpendicular dimensions.
Larger X coordinate	m	1,550	-80,000 – +80,000	P	See above.
Smaller Y coordinate	m	-2,450	-80,000 – +80,000	P	See above
Larger Y coordinate	m	550	-80,000 – +80,000	P	See above.
Runoff coefficient	–	0.2	0–1	P	See “Primary contamination area runoff coefficient” parameter.
Soil erodibility factor	tons/acre	0.4	0–0.5	P	See “Contaminated zone soil erodibility factor” parameter.
Slope-length/steepness factor	–	0.4	–10	P	See “Primary contamination area slope-length/steepness factor” parameter.
Cover and management factor	–	0.003	0–1	B, P	See “Primary contamination area cover and management factor” parameter.
Support practice factor	–	1	0–1	B, P	See “Primary contamination area support practice factor” parameter.
Sediment from catchment delivery ratio	–	0.2121	0 – 1	P	This is the fraction of the soil that eroded from the catchment and reached the surface water body.
Fraction of deposited radionuclides reaching surface water body	–	0.02	0 – 0.1	P	Fraction of radionuclides that was deposited on the catchment and washed out into the surface water body.
Computing deposition on catchment	–	Model it	Model it or use the release which is the upper bound		Atmospheric deposition on the catchment area can be modeled or approximated by the atmospheric release.

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Table A-5 Parameters and Their Default Values Used in RESRAD-OFFSITE V4.0 (cont.)

Input Screen Title and Parameter Name	Units	Default Value[a]	Code-Accepted Values[b] Physical or Numerical[c] (N) Range	Type[d]	Description
Surface Water Body (cont.)					
Characteristics of catchment area					
Convergence criterion of atmospheric deposition	–	0.001	0 – 0.1	P	Conversion criteria for the areal integration of the atmospheric transport from the primary contamination to the catchment.
Ingestion Rates					
Consumption rate					
Drinking water intake	L/yr	510	0–1,000	M, B	This is the amount of water that is consumed by a single individual in a year.
Fish consumption	kg/yr	5.4	0–1,000	M, B	This is the weight of fish that is consumed by a single individual in a year.
Other aquatic food consumption	kg/yr	0.9	0–100	M, B	This is the weight of other aquatic organisms that is consumed by a single individual in a year.
Fruit, grain, nonleafy vegetables consumption	kg/yr	160	0–1,000	M, B	This is the weight of nonleafy vegetables, fruits, or grain that is consumed by a single individual in a year.
Leafy vegetables consumption	kg/yr	14	0–100	M, B	This is the weight of leafy vegetables that is consumed by a single individual in a year.
Meat consumption	kg/yr	63	0–300	M, B	This is the weight of meat that is consumed by a single individual in a year.
Milk consumption	L/yr	92	0–1,000	M, B	This is the weight of milk that is consumed by a single individual in a year.
Soil (incidental) ingestion rate	g/yr	36.5	0–10,000	M, B	This is the quantity of soil ingested by a single individual in a year.
Fraction from affected area					
Drinking water intake fraction from affected area	–	1	0–1	B, P	This is the fraction of drinking water consumed by an individual that is obtained from the contaminated area.
Fish consumption fraction from affected area	–	0.5	0–1	B, P	This is the fraction of fish consumed by an individual that is obtained from the contaminated surface water body.
Other aquatic food consumption fraction from affected area	–	0.5	0–1	B, P	This is the fraction of the other aquatic food consumed by an individual that is obtained from the contaminated surface water body.
Fruit, grain, nonleafy vegetables consumption fraction from affected area	–	0.5	0–1	B, P	This is the fraction of fruit, nonleafy vegetables, or grain consumed by an individual that is obtained from contaminated agricultural areas.

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[c] Numerical range is the range defined in a program file to prevent code crashes.

[d] P = physical, B = behavioral, M = metabolic; when more than one type is listed, the first is primary and the next is secondary.

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[f] NA = not applicable.

Table A-5 Parameters and Their Default Values Used in RESRAD-OFFSITE V4.0 (cont.)

Input Screen Title and Parameter Name	Units	Default Value[a]	Code-Accepted Values[b] Physical or Numerical[c] (N) Range	Type[d]	Description
Ingestion Rates (cont.)					
Fraction from affected area					
Leafy vegetables consumption fraction from affected area	–	0.5	0–1	B, P	This is the fraction of leafy vegetables consumed by an individual that is obtained from contaminated agricultural areas.
Meat consumption fraction from affected area	–	1	0–1	B, P	This is the fraction of meat consumed by an individual that is produced using contaminated feed and water.
Milk consumption fraction from affected area	–	1	0–1	B, P	This is the fraction of milk consumed by an individual that is produced using contaminated feed and water.
Plant Factors					
Fruit, grain, nonleafy vegetables					
Wet weight crop yield of fruit, grain, and nonleafy vegetables	kg/m^2	0.7	0.01–3	P	This is the mass (wet weight) of the edible portion of fruit, grain, and nonleafy vegetables produced from a unit land area.
Duration of growing season of fruit, grain, and nonleafy vegetables	yr	0.17	0.01–1	P	This is the period of time during which the fruit, grain, and nonleafy vegetables are exposed to contamination by foliar deposition and root uptake.
Foliage to food transfer coefficient of fruit, grain, and nonleafy vegetables	–	0.1	0–1	P	This is the contaminant foliage-to-food transfer coefficient. A fraction of the contaminants that retain on foliage of the fruit, grain, and nonleafy vegetables will be absorbed and transferred to the edible portion of the pasture and silage.
Weathering removal constant of fruit, grain, and nonleafy vegetables	1/yr	20	1–40	P	The weathering process would remove contaminants from foliage of the fruit, grain, and nonleafy vegetables. The process is characterized by a removal constant and reduces the amount of contaminants on foliage exponentially during the exposure period.
Foliar interception factor for irrigation of fruit, grain, and nonleafy vegetables	–	0.25	0–1	P	This is the fraction of deposited radionuclides from irrigation that is retained on the foliage of the fruit, grain, and nonleafy vegetables.

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Table A-5 Parameters and Their Default Values Used in RESRAD-OFFSITE V4.0 (cont.)

Input Screen Title and Parameter Name	Units	Default Value[a]	Code-Accepted Values[b] Physical or Numerical[c] (N) Range	Type[d]	Description
Plant Factors (cont.)					
Fruit, grain, nonleafy vegetables					
Foliar interception factor for dust of fruit, grain, and nonleafy vegetables	–	0.25	0–1	P	This is the fraction of deposited radionuclides from mass loading that is retained on the foliage of the fruit, grain, and nonleafy vegetables.
Root depth of fruit, grain, and nonleafy vegetables	m	1.2	0–10	P	This is the maximum root depth of the fruit, grain, and nonleafy vegetables.
Leafy vegetables					
Wet weight crop yield of leafy vegetables	kg/m^2	1.5	0.01 – 3	P	This is the mass (wet weight) of the edible portion of leafy vegetables produced from a unit land area.
Duration of growing season of leafy vegetables	yr	0.25	0.01 – 1	P	This is the period of time during which the leafy vegetables are exposed to contamination by foliar deposition and root uptake.
Foliage to food transfer coefficient of leafy vegetables	–	1	0 – 1	P	This is the contaminant foliage-to-food transfer coefficient. A fraction of the contaminants that retain on foliage of the leafy vegetables will be absorbed and transferred to the edible portion of the pasture and silage.
Weathering removal constant of leafy vegetables	1/yr	20	1–40	P	The weathering process would remove contaminants from foliage of the leafy vegetables. The process is characterized by a removal constant and reduces the amount of contaminants on foliage exponentially during the exposure period.
Foliar interception factor for irrigation of leafy vegetables	–	0.25	0–1	P	This is the fraction of deposited radionuclides from irrigation that retains on the foliage of the leafy vegetables.
Foliar interception factor for dust of leafy vegetables	–	0.25	0–1	P	This is the fraction of deposited radionuclides from mass loading that retains on the foliage of the leafy vegetables.
Root depth of leafy vegetables	M	0.9	0–3	P	This is the maximum root depth of the leafy vegetables.
Livestock Intakes					
Beef cattle					
Water intake for beef cattle	L/d	50	0–500	M	This is the daily intake of water by cows kept for meat production.

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Table A-5 Parameters and Their Default Values Used in RESRAD-OFFSITE V4.0 (cont.)

Input Screen Title and Parameter Name	Units	Default Value[a]	Code-Accepted Values[b] Physical or Numerical[c] (N) Range	Type[d]	Description
Livestock Intakes (cont.)					
Beef cattle					
Pasture and silage intake for beef cattle	kg/d	14	0–300	M	This is the daily intake of silage or pasture by cows kept for meat production.
Grain intake for beef cattle	kg/d	54	0–300	M	This is the daily intake of grain by cows kept for meat production.
Soil from pasture and silage intake for beef cattle	kg/d	0.1	0–10	M	This is the daily incidental intake of soil with silage or pasture by cows kept for meat production.
Soil from grain intake for beef cattle	kg/d	0.4	0–10	M	This is the daily incidental intake of soil with grain by cows kept for meat production.
Dairy cows					
Water intake for dairy cows	L/d	160	0–500	M	This is the daily intake of water by cows kept for milk production.
Pasture and silage intake for dairy cows	kg/d	44	0–300	M	This is the daily intake of silage or pasture by cows kept for milk production.
Grain intake for dairy cows	kg/d	11	0–300	M	This is the daily intake of grain by cows kept for milk production.
Soil from pasture and silage intake for dairy cows	kg/d	0.4	0–10	M	This is the daily incidental intake of soil with silage or pasture by cows kept for milk production.
Soil from grain intake for dairy cows	kg/d	0.1	0–10	M	This is the daily incidental intake of soil with grain by cows kept for milk production.
Pasture and silage					
Wet weight crop yield of pasture and silage	kg/m^2	1.1	0.01 – 3	P	This is the mass (wet weight) of the edible portion of pasture and silage that is consumed by livestock produced from a unit land area.
Duration of growing season of pasture and silage	yr	0.08	0.01–1	P	This is the period of time during which the pasture and silage that is consumed by livestock is exposed to contamination by foliar deposition and root uptake.
Foliage to food transfer coefficient of pasture and silage	–	1	0–1	P	This is the contaminant foliage-to-food transfer coefficient. A fraction of the contaminants that retains on foliage of the pasture and silage that will be absorbed and transferred to the edible portion of the pasture and silage that is consumed by livestock.

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[b] Code-accepted values are not provided for element- or nuclide-specific parameters.
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Table A-5 Parameters and Their Default Values Used in RESRAD-OFFSITE V4.0 (cont.)

Input Screen Title and Parameter Name	Units	Default Value[a]	Code-Accepted Values[b] Physical or Numerical[c] (N) Range	Type[d]	Description
Livestock Feed Factors (cont.)					
Pasture and silage					
Weathering removal constant of pasture and silage	1/yr	20	1–40	P	The weathering process would remove contaminants from foliage of the pasture and silage that is consumed by livestock. The process is characterized by a removal constant and reduces the amount of contaminants on foliage exponentially during the exposure period.
Foliar interception factor for irrigation of pasture and silage	–	0.25	0–1	P	This is the fraction of deposited radionuclides from irrigation that retains on the foliage of the pasture and silage food that is consumed by livestock.
Foliar interception factor for dust of pasture and silage	–	0.25	0–1	P	This is the fraction of deposited radionuclides from mass loading that retains on the foliage of the pasture and silage food that is consumed by livestock.
Root depth of pasture and silage	m	0.9	0–3	P	This is the maximum root depth of the pasture and silage that is consumed by livestock.
Grain					
Wet weight crop yield of grain	kg/m^2	0.7	0.01–3	P	This is the mass (wet weight) of the edible portion of grain that is consumed by livestock produced from a unit land area.
Duration of growing season of grain	yr	0.17	0.01–1	P	This is the period of time during which the grain that is consumed by livestock is exposed to contamination by foliar deposition and root uptake.
Foliage to food transfer coefficient of grain	–	0.1	0–1	P	This is the contaminant foliage-to-food transfer coefficient. A fraction of the contaminants that retain on foliage of the grain that is consumed by livestock will be absorbed and transferred to the edible portion of the grain.
Weathering removal constant of grain	1/yr	20	1–40	P	The weathering process would remove contaminants from foliage of the grain that is consumed by livestock. The process is characterized by a removal constant and reduces the amount of contaminants on foliage exponentially during the exposure period.
Foliar interception factor for irrigation of grain	–	0.25	0–1	P	This is the fraction of deposited radionuclides from irrigation that retains on the foliage of the grain that is consumed by livestock.

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Table A-5 Parameters and Their Default Values Used in RESRAD-OFFSITE V4.0 (cont.)

Input Screen Title and Parameter Name	Units	Default Value[a]	Code-Accepted Values[b] Physical or Numerical[c] (N) Range	Type[d]	Description
Livestock Feed Factors (cont.)					
Grain					
Foliar interception factor for dust of grain	–	0.25	0–1	P	This is the fraction of deposited radionuclides from mass loading that retains on the foliage of the grain that is consumed by livestock.
Root depth of grain	m	1.2	0–10	P	This is the maximum root depth of the grain that is consumed by livestock.
Inhalation and External Gamma Shielding					
Inhalation rate	m^3/yr	8,400	0–20,000	M, B	This is the annual air intake.
Mass loading of all particulates from primary contamination	g/m^3	0.0001	0–2	P, B	This is the mass loading of airborne contaminated soil particles.
Respirable particulates as a fraction of total particulates	–	1	0–1	P	Fraction of total particulates originating from the primary contamination that are of respirable size.
Mass loading and respirable fraction at offsite locations	–	Input different values	Use same value as for primary contamination, input different values	P	User has an option to choose to use same value of mass loading and respirable fraction at offsite locations as for primary contamination, or input different values.
Mass loading of all particulates from nonleafy vegetable field	g/m^3	0.0001	0–2	P, B	This is the mass loading of particulates of all sizes originating from the nonleafy vegetable field.
Respirable fraction from nonleafy vegetable field	–	1	0–1	P	This is the fraction of the particulates originating from the nonleafy vegetable field that are of the respirable size.
Mass loading of all particulates from pasture and silage field	g/m^3	0.0001	0–2	P, B	This is the mass loading of particulates of all sizes originating from the pasture and silage field.
Respirable fraction from pasture and silage field	–	1	0–1	P	This is the fraction of the particulates originating from the pasture and silage field that are of the respirable size.
Mass loading of all particulates from grain field	g/m^3	0.0001	0–2	P, B	This is the mass loading of particulates of all sizes originating from the grain field.
Respirable fraction from grain field	–	1	0–1	P	This is the fraction of the particulates originating from the grain field that are of respirable size.

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Table A-5 Parameters and Their Default Values Used in RESRAD-OFFSITE V4.0 (cont.)

Input Screen Title and Parameter Name	Units	Default Value[a]	Code-Accepted Values[b] Physical or Numerical[c] (N) Range	Type[d]	Description
Inhalation and External Gamma Shielding (cont.)					
Mass loading of all particulates from offsite dwelling	g/m^3	0.0001	0–2	P, B	This is the mass loading of particulates of all sizes originating from the offsite dwelling.
Respirable fraction from offsite dwelling	–	1	0–1	P	This is the fraction of the particulates originating from the offsite dwelling that are of the respirable size.
Indoor dust filtration factor (indoor to outdoor dust concentration ratio)	–	0.4	0–1	P, B	The indoor dust filtration factor describes the effect of the building structure on the level of contaminated dust existing indoors. Specifically, the factor is the fraction of outdoor contaminated dust that will be available indoors.
External gamma shielding (penetration) factor	–	0.7	0–1	P	The shielding factor describes the effect of the building structure on the level of gamma radiation existing indoors. Specifically, the shielding factor is the fraction of outdoor gamma radiation that will be available indoors.
External Radiation Shape and Area Factors					
Scale	m	200	>0–32,000	P	This sets the lengths of the sides of the square frame within which the primary contamination is to be drawn. The scale should be chosen to fully encompass the primary contamination. If the mouse is used to specify the locations of the dwellings, the scale must be chosen so that the primary contamination and the dwellings can be located in the drawing frame.
Dwelling location coordinate in X-direction	m	100	-16,000 – +16,000	P	The point locations of the onsite and offsite dwellings can be specified either by inputting the coordinates or by clicking on the figure. First select the tab corresponding to the dwelling location (onsite or offsite). Then key in the coordinates of the dwelling location in these input boxes. Click the Calculate Radii and Fractions button after entering the coordinates of each dwelling location to compute the radii and fractions.
Dwelling location coordinate in Y-direction	m	0	-16,000 – +16,000	P	See above.

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Table A-5 Parameters and Their Default Values Used in RESRAD-OFFSITE V4.0 (cont.)

Input Screen Title and Parameter Name	Units	Default Value[a]	Code-Accepted Values[b] Physical or Numerical[c] (N) Range	Type[d]	Description
External Radiation Shape and Area Factors (cont.)					
Radii from onsite dwelling	m	6 12 18 24 30 36 42 48 54 60 66 72	Calculated by code, can be over written by user 1E-34–1E+34 **(N)**	P	The radii and fraction are calculated by the code by drawing 12 concentric circles centered at the dwelling location. The radius of the outermost circle is such that it encloses the entire primary contamination. The radius of the innermost circle is 1/12 of the radius of the outermost circle. The radii of the remaining 10 circles are in an arithmetic series between the radii of these two circles. The interface then estimates the fraction of each annular ring that is within the primary contamination displayed in the graphic. The radii of the 12 concentric circles and the fractional area of each annular ring within the primary contamination are displayed in the 12 radii and fraction input boxes in the tab corresponding to the receptor location. The user can directly input the radii and fraction information if it is available.
Fraction of annulus from onsite dwelling that is within the primary contamination	–	1 1 1 1 1 1 1 1 0.78 0.37 0.17 0.035	Calculated by code, can be over written by user 0–1	P	See above.

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Table A-5 Parameters and Their Default Values Used in RESRAD-OFFSITE V4.0 (cont.)

Input Screen Title and Parameter Name	Units	Default Value[a]	Code-Accepted Values[b] Physical or Numerical[c] (N) Range	Type[d]	Description
External Radiation Shape and Area Factors (cont.)					
Radii from offsite dwelling	m	13.25 26.5 39.75 53.0 66.25 79.5 92.75 106 119.25 132.5 145.75 159	Calculated by code can be overwritten by user 1E-34 – 1E+34	P	The radii and fraction are calculated by the code by drawing 12 concentric circles centered at the dwelling location. The radius of the outermost circle is such that it encloses the entire primary contamination. The radius of the innermost circle is 1/12 of the radius of the outermost circle. The radii of the remaining 10 circles are in an arithmetic series between the radii of these two circles. The interface then estimates the fraction of each annular ring that is within the primary contamination displayed in the graphic. The radii of the 12 concentric circles and the fractional area of each annular ring within the primary contamination are displayed in the 12 radii and fraction input boxes in the tab corresponding to the receptor location. The user can directly input the radii and fraction information if it is available.
Fractions of annulus from offsite dwelling, that is within the primary contamination	–	0 0 0 0.024 0.19 0.24 0.2 0.17 0.15 0.13 0.12 0.052	Calculated	P	See above.
Shape of the primary contamination	–	Polygonal	Circular or polygonal	P	This defines the shape of the primary contamination.

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[b] Code-accepted values are not provided for element- or nuclide-specific parameters.

[c] Numerical range is the range defined in a program file to prevent code crashes.

[d] P = physical, B = behavioral, M = metabolic; when more than one type is listed, the first is primary and the next is secondary.

[e] "–" indicates that the parameter is dimensionless.

[f] NA = not applicable.

Table A-5 Parameters and Their Default Values Used in RESRAD-OFFSITE V4.0 (cont.)

Input Screen Title and Parameter Name	Units	Default Value[a]	Code-Accepted Values[b] Physical or Numerical[c] (N) Range	Type[d]	Description
External Radiation Shape and Area Factors (cont.)					
X coordinate of the vertices of the polygon of the primary contamination	m	None	-16,000 – +16,000	P	If the user has more information on the shape of the primary contamination, they can press "clear" to clear the previous shape and draw the exact shape of the polygon or input X and Y coordinates of the polygon's vertices. The polygon can be drawn using the mouse and instructions given in the yellow information box on the form. Alternatively, the polygon's vertices can keyed in by following the instructions given in the green instructions box.
Y coordinate of the vertices of the polygon of the primary contamination	m	None	-16,000 – +16,000	P	See above.
Occupancy					
Fraction of time spent on primary contamination (whether cultivated or not)					
Indoor time fraction on primary contamination	–	0	0–1	B	This is the average fraction of time during which an individual stays inside a house that is built on top of the primary contamination.
Outdoor time fraction on primary contamination	–	0	0–1	B	This is the average fraction of time during which an individual stays outdoors on the area of primary contamination.
Fraction of time spent in offsite dwelling site					
Indoor time fraction on offsite dwelling site	–	0.5	0–1	B	This is the average fraction of time during which an individual stays inside a house that is built outside the area of primary contamination.
Outdoor time fraction on offsite dwelling site	–	0.1	0–1	B	This is the average fraction of time during which an individual stays outdoors in the offsite dwelling site.
Fraction of time spent in farmed areas (including primary and secondary contaminated areas)					
Time fraction in fruit, grain, and nonleafy vegetable fields	–	0.1	0–1	B	This is the average fraction of a day during which an individual stays in the agricultural field or pasture (farmed area).
Time fraction in leafy vegetable fields	–	0.1	0–1	B	

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[b] Code-accepted values are not provided for element- or nuclide-specific parameters.
[c] Numerical range is the range defined in a program file to prevent code crashes.
[d] P = physical, B = behavioral, M = metabolic; when more than one type is listed, the first is primary and the next is secondary.
[e] "–" indicates that the parameter is dimensionless.
[f] NA = not applicable.

Table A-5 Parameters and Their Default Values Used in RESRAD-OFFSITE V4.0 (cont.)

Input Screen Title and Parameter Name	Units	Default Value[a]	Code-Accepted Values[b] Physical or Numerical[c] (N) Range	Type[d]	Description
Occupancy (cont.)					
Fraction of time spent in farmed areas (including primary and secondary contaminated areas)					
Time fraction in pasture and silage fields	–	0.1	0–1	B	
Time fraction in livestock grain fields	–	0.1	0–1	B	
Radon					
Effective radon diffusion coefficient of cover	m^2/s	2.0E-06	0–1 or -1	P	The effective (or interstitial) radon diffusion coefficient is defined as the ratio of the gradient of the radon activity concentration in the pore space to the diffusive flux density of radon activity across the pore area. Entering -1 for any diffusion coefficient will cause the code to calculate a diffusion coefficient based on the porosity and water content of the medium.
Effective radon diffusion coefficient of contaminated zone	m^2/s	2.0E-06	0–1 or -1	P	Same as above.
Effective radon diffusion coefficient of floor	m^2/s	3.0E-07	0–1 or -1	P	Same as above.
Thickness of floor and foundation	m	0.15	0–10	P	The building foundation thickness is defined as the average thickness of the building shell structure in the subsurface of the soil.
Density of floor and foundation	g/cm^3	2.4	0–22.5	P	The building foundation bulk density is defined as the ratio of the solid-phase mass to the total volume.
Total porosity of floor and foundation	–	0.1	1E-04–1	P	Total porosity is defined as the ratio of the void-space volume to the total volume of a porous medium.
Volumetric water content of floor and foundation	–	0.03	0–1	P	The volumetric water content in a porous medium represents the fraction of the total volume of the porous medium that is occupied by the water contained in it. The value should be less than the total porosity of the porous medium.

[a] The default values listed in this table are the default values in the RESRAD-OFFSITE V4.0.
[b] Code-accepted values are not provided for element- or nuclide-specific parameters.
[c] Numerical range is the range defined in a program file to prevent code crashes.
[d] P = physical, B = behavioral, M = metabolic; when more than one type is listed, the first is primary and the next is secondary.
[e] "–" indicates that the parameter is dimensionless.
[f] NA = not applicable.

Table A-5 Parameters and Their Default Values Used in RESRAD-OFFSITE V4.0 (cont.)

Input Screen Title and Parameter Name	Units	Default Value[a]	Code-Accepted Values[b] Physical or Numerical[c] (N) Range	Type[d]	Description
Radon (cont.)					
Depth of foundation below ground level	m	-1	0–100 or -100	P	The foundation depth below ground surface is defined as the vertical distance in the soil immediately from the bottom of the basement floor slab to the ground surface. If a negative value is entered, the absolute value will be adjusted (if needed) so that the foundation depth will not extend into the contaminated zone. Thus, due to erosion of the cover and contaminated zones, the foundation depth could be time-dependent and less than the (absolute) specified value.
Vertical dimension of mixing	m	2	1E-04–1,000	P	Radon vertical dimension of mixing is defined as the height into which the plume of radon is uniformly mixed in the outdoor air.
Building room height	m	2.5	1E-04–100	P	The building room height is defined as the average height of the rooms in the building.
Building air exchange rate	1/hr	0.5	0–1,000	B	The building air exchange (or ventilation) rate is defined as the number of the total volumes of air in the building being exchanged with outside air per unit of time.
Building indoor area factor	–	0	0–100	P	The building indoor area factor is the fraction of the floor area built on the contaminated area. Values greater than 1 indicate a contribution from walls extending into the contaminated zone. A default value of 0 means the code will calculate automatically a time-dependent area factor on the basis of an assumed floor area of 100 m^2 and the amount of wall area extending into the contaminated zone.
Rn-222 emanation coefficient	–	0.25	1E-02–1	P	The radon emanation coefficient is defined as the fraction of the total radon generated by radium decay that escapes from the soil particles. The emanating power is dependent upon on many factors, such as mineralogy, porosity, particle size distribution, and moisture content.
Rn-220 emanation coefficient	–	0.15	1E-02–1	P	Same as above.

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[b] Code-accepted values are not provided for element- or nuclide-specific parameters.
[c] Numerical range is the range defined in a program file to prevent code crashes.
[d] P = physical, B = behavioral, M = metabolic; when more than one type is listed, the first is primary and the next is secondary.
[e] "–" indicates that the parameter is dimensionless.
[f] NA = not applicable.

Table A-5 Parameters and Their Default Values Used in RESRAD-OFFSITE V4.0 (cont.)

Input Screen Title and Parameter Name	Units	Default Value[a]	Code-Accepted Values[b] Physical or Numerical[c] (N) Range	Type[d]	Description
Radon (cont.)					
Effective radon diffusion coefficient of nonleafy vegetable field	m^2/s	2.0E-06	0–1 or -1	P	See "Effective radon diffusion coefficient of cover".
Effective radon diffusion coefficient of leafy vegetable field	m^2/s	2.0E-06	0–1 or -1	P	See "Effective radon diffusion coefficient of cover".
Effective radon diffusion coefficient of pasture	m^2/s	2.0E-06	0–1 or -1	P	See "Effective radon diffusion coefficient of cover".
Effective radon diffusion coefficient of livestock grain	m^2/s	2.0E-06	0–1 or -1	P	See "Effective radon diffusion coefficient of cover".
Effective radon diffusion coefficient of offsite dwelling site	m^2/s	2.0E-06	0–1 or -1	P	See "Effective radon diffusion coefficient of cover".
Carbon-14 and Carbon-12					
Thickness of evasion layer for C-14 in soil	m	0.3	0–10	P	This is the maximum soil thickness layer through which C-14 can escape to the air by conversion to CO_2. C-14 below this depth is assumed trapped in the soil.
Vertical dimension of mixing for inhalation	m	2	0.0001-1,000	P	This vertical dimension together with the area of the primary contamination is used to compute the onsite concentrations of C-14 for inhalation.
Vertical dimension of mixing for vegetation	m	1	0.0001-1000	P	This vertical dimension together with the area of the primary contamination is used to compute the onsite concentrations of C-14 for vegetation.
C-14 evasion flux rate from soil	1/s	7.0E-07	0–1	P	This is the fraction of C-14 in soil that escapes to the atmosphere per unit time.
C-12 evasion flux rate from soil	1/s	1.0E-10	0–1	P	This is the fraction of C-12 in soil that escapes to the atmosphere per unit time.
Fraction of vegetation carbon absorbed from soil	–	0.02	1E-04–1	P	This is the fraction of total vegetation carbon obtained by direct root uptake from the soil.

[a] The default values listed in this table are the default values in the RESRAD-OFFSITE V4.0.
[b] Code-accepted values are not provided for element- or nuclide-specific parameters.
[c] Numerical range is the range defined in a program file to prevent code crashes.
[d] P = physical, B = behavioral, M = metabolic; when more than one type is listed, the first is primary and the next is secondary.
[e] "–" indicates that the parameter is dimensionless.
[f] NA = not applicable.

Table A-5 Parameters and Their Default Values Used in RESRAD-OFFSITE V4.0 (cont.)

Input Screen Title and Parameter Name	Units	Default Value[a]	Code-Accepted Values[b] Physical or Numerical[c] (N) Range	Type[d]	Description
Carbon-14 and Carbon-12 (cont.)					
Fraction of vegetation carbon absorbed from air	–	0.98	0–1	P	This is the fraction of total vegetation carbon assimilated from the atmosphere through photosynthesis.
Mass Fractions and Concentrations of Carbon-12					
C-12 concentration in the atmosphere	g/m^3	0.18	0.1–0.3	P	This is the C-12 concentration in the atmosphere.
C-12 concentration in contaminated soil	g/g	0.03	1E-04–1	P	This is the C-12 concentration in the contaminated zone.
C-12 concentration in local water	g/cm^3	0.00002	0–100	P	This is the C-12 concentration in the local water.
C-12 mass fraction in fruit, grain, nonleafy vegetables	–	0.4	0–1	P	This is the mass of C-12 in a unit mass of fruit, grain, and nonleafy vegetables.
C-12 mass fraction in leafy vegetables	–	0.09	0–1	P	This is the mass of C-12 in a unit mass of leafy vegetables.
C-12 mass fraction in pasture and silage	–	0.09	0–1	P	This is the mass of C-12 in a unit mass of pasture and silage.
C-12 mass fraction in livestock feed grain	–	0.4	0–1	P	This is the mass of C-12 in a unit mass of grain.
C-12 mass fraction in meat	–	0.24	0–1	P	This is the mass of C-12 in a unit mass of meat.
C-12 mass fraction in milk	–	0.07	0–1	P	This is the mass of C-12 in a unit mass of milk.
Tritium (H-3)					
Humidity in air	g/m^3	8	0–1,000	P	Air humidity is used for the computation of tritium concentrations in air.
Mass fraction of water:					
Water fraction in fruit, grain, nonleafy vegetables	–	0.8	0–1	P	This is the mass of water in a unit mass of fruit, grain, and nonleafy vegetables.
Water fraction in leafy vegetables	–	0.8	0–1	P	This is the mass of water in a unit mass of leafy vegetables.
Water fraction in pasture and silage	–	0.8	0–1	P	This is the mass of water in a unit mass of pasture and silage.

[a] The default values listed in this table are the default values in the RESRAD-OFFSITE V4.0.
[b] Code-accepted values are not provided for element- or nuclide-specific parameters.
[c] Numerical range is the range defined in a program file to prevent code crashes.
[d] P = physical, B = behavioral, M = metabolic; when more than one type is listed, the first is primary and the next is secondary.
[e] "–" indicates that the parameter is dimensionless.
[f] NA = not applicable.

Table A-5 Parameters and Their Default Values Used in RESRAD-OFFSITE V4.0 (cont.)

Input Screen Title and Parameter Name	Units	Default Value[a]	Code-Accepted Values[b] Physical or Numerical[c] (N) Range	Type[d]	Description
Tritium (H-3) (cont.)					
Mass fraction of water:					
Water fraction in livestock feed grain	–	0.8	0–1	P	This is the mass of water in a unit mass of livestock feed grain.
Water fraction in meat	–	0.6	0–1	P	This is the mass of water in a unit mass of meat.
Water fraction in milk	–	0.88	0–1	P	This is the mass of water in a unit mass of milk.
Vertical dimension of mixing for inhalation	m	2	0.0001-1000	P	This vertical dimension together with the area of the primary contamination is used to compute the onsite concentrations of tritium.

[a] The default values listed in this table are the default values in the RESRAD-OFFSITE V4.0.

[b] Code-accepted values are not provided for element- or nuclide-specific parameters.

[c] Numerical range is the range defined in a program file to prevent code crashes.

[d] P = physical, B = behavioral, M = metabolic; when more than one type is listed, the first is primary and the next is secondary.

[e] "–" indicates that the parameter is dimensionless.

[f] NA = not applicable.

Table A-6 Parameters and Their Default Values Used in RESRAD-BUILD V3.5

Parameter Name	Pathways Used	Unit	Default Value	Code-Accepted Values[a]	Type[b]	Reference	Description
Case							
Title	All	–[c]	Default Case for RESRAD-BUILD	80 alphabetic or numeric characters	NA		The Title is used to identify the run and can be up to 80 alphabetic or numeric characters long.
Dose/Risk Library	All	–	FGR 11	FGR 11, FGR 12, FGR 13 Morbidity, FGR 13 Mortality, HEAST 2001 Morbidity, ICRP 72 (Adult), ICRP 72 (Age 1), ICRP 72 (Age 10), ICRP 72 (Age 5), ICRP 72 (Age 15), ICRP 72 (Infant), User supplied	NA		The Dose/Risk library contains the dose and risk coefficients used in the calculations. The user can select from the available default libraries or create their own library using DCF Editor.
Time Parameters							
Exposure duration	All	d	365	>0	B	Yu et al., 2003	The time spanned by the dose assessment, including intervals during which receptors may be absent from the building. It is used to calculate the amount of time at each receptor location as: time at receptor location = exposure duration × fraction of time inside × fraction of time at receptor location.
Indoor fraction	All	–	0.5	0–1	B	Yu et al., 2003	The fraction of total time spent by one or more receptors inside a building.
Evaluation Times							
Times for calculation	All	yr	1	0–100,000	P	Yu et al., 2003	The times at which the dose assessment is performed (other than time zero). Dose can be calculated at nine user specified times. Dose is always calculated at time zero.

[a] Code-accepted values are not provided for nuclide-specific parameters.
[b] P = physical, B = behavioral, and M = metabolic; when more than one type is listed, the first is primary and the next is secondary. NA = not applicable.
[c] "–" indicates that the parameter is dimensionless.
[d] Value for this parameter will appear only if more than one room is selected in the "number of rooms" parameter.
[e] Value for this parameter will not appear if the selected source type is a point source.
[f] Value for this parameter will appear only if the selected source type is other than a volume source.
[g] Value for this parameter will appear only if at least one of the selected radionuclides is a radon precursor.
[h] The tritium evaporation model implemented in the RESRAD-BUILD code was adapted from the land farming model developed by Thibodeaux and Hwang (1982) to consider evaporation of hydrocarbons from contaminated soils.

Table A-6 Parameters and Their Default Values Used in RESRAD-BUILD V3.5 (cont.)

Parameter Name	Pathways Used	Unit	Default Value	Code-Accepted Values[a]	Type[b]	Reference	Description
Time Parameters (cont.)							
Evaluation Times							
Maximum number of time integration points	All	–	17	1, 2, 3, 5, 9, 17, 33, 65, 129, 257	P	Yu et al., 2003	The number of points to calculate the time-integrated dose. If the user selects 1, then the instantaneous dose at the user-specified time is calculated.
Building Parameters							
Number of rooms	All except direct external	–	1	1, 2, 3	P	Yu et al., 2003	The maximum number of rooms in the building being modeled. Maximum rooms allowed are three.
Deposition velocity	All except direct external	m/s	0.01	≥ 0	P	Yu et al., 2003	The indoor deposition velocity of contaminant particles in the building air.
Resuspension rate	All except direct external	1/s	5.00E-07	≥ 0	P, B	Yu et al., 2003	The fraction of the deposited particles resuspended into the air per unit of time.
Room Details							
Room height	All except direct external	m	2.5	> 0	P	Yu et al., 2003	The height of each distinct air flow volume.
Room area	All except direct external	m^2	36	> 0	P	Yu et al., 2003	The floor area of each distinct air flow volume.
Air exchange rate for building and room	All except direct external	1/h	0.8	≥ 0	B	Yu et al., 2003	The rate at which the total amount of air contained within the building or room is replaced or renewed per unit time.

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[c] "–" indicates that the parameter is dimensionless.
[d] Value for this parameter will appear only if more than one room is selected in the "number of rooms" parameter.
[e] Value for this parameter will not appear if the selected source type is a point source.
[f] Value for this parameter will appear only if the selected source type is other than a volume source.
[g] Value for this parameter will appear only if at least one of the selected radionuclides is a radon precursor.
[h] The tritium evaporation model implemented in the RESRAD-BUILD code was adapted from the land farming model developed by Thibodeaux and Hwang (1982) to consider evaporation of hydrocarbons from contaminated soils.

Table A-6 Parameters and Their Default Values Used in RESRAD-BUILD V3.5 (cont.)

Parameter Name	Pathways Used	Unit	Default Value	Code-Accepted Values[a]	Type[b]	Reference	Description
Building Parameters (cont.)							
Room Details							
Flow rate between rooms	All except direct external	m^3/h	30[d]	Unlimited	B	Yu et al., 2003	The rates at which air flows in each direction between adjacent rooms. The net flow rate between two rooms may be positive, zero, or negative. This parameter is not applicable for the default configuration, which is one room.
Outdoor inflow and outflow	All except direct external	m^3/h	72	Unlimited	B, P	Yu et al., 2003	The rates at which air flows between the rooms and the exterior of the building.
Radiological Units							
Unit for activity	All	–	pCi	Traditional or SI	NA		The code accepts values in traditional units or SI units.
Unit for dose	All	–	mrem	Traditional or SI	NA		The code accepts values in traditional units or SI units.

[a] Code-accepted values are not provided for nuclide-specific parameters.
[b] P = physical, B = behavioral, and M = metabolic; when more than one type is listed, the first is primary and the next is secondary. NA = not applicable.
[c] "–" indicates that the parameter is dimensionless.
[d] Value for this parameter will appear only if more than one room is selected in the "number of rooms" parameter.
[e] Value for this parameter will not appear if the selected source type is a point source.
[f] Value for this parameter will appear only if the selected source type is other than a volume source.
[g] Value for this parameter will appear only if at least one of the selected radionuclides is a radon precursor.
[h] The tritium evaporation model implemented in the RESRAD-BUILD code was adapted from the land farming model developed by Thibodeaux and Hwang (1982) to consider evaporation of hydrocarbons from contaminated soils.

Table A-6 Parameters and Their Default Values Used in RESRAD-BUILD V3.5 (cont.)

Parameter Name	Pathways Used	Unit	Default Value	Code-Accepted Values[a]	Type[b]	Reference	Description
Receptor Parameters							
Number of receptors	All	–	1	1–10	B	Yu et al., 2003	The number of distinct combinations of locations, time fractions, and intake characteristics for one or more individuals who are subject to dose assessment. Each combination is identified by a number which is used to define/input the characteristics of that combination.
Receptor room	All except direct external	–	1	1–3	B	Yu et al., 2003	The room in which an individual receptor is located.
Receptor location	Direct external	m	1,1,1 (Cartesian coordinates)	Unlimited	B	Yu et al., 2003	The spatial coordinates of the point occupied by a receptor.
Receptor time fraction	All	–	1	0–1	B	Yu et al., 2003	The fraction of time spent by one receptor at a given location while inside the building.
Receptor inhalation rate	Inhalation and radon	m^3/d	18	>0	M, B	Yu et al., 2003	The rate at which an individual inhales air at the receptor location. The dose could be 0 from these pathways if the inhalation rate is 0 or the injection rate is 0.

[a] Code-accepted values are not provided for nuclide-specific parameters.
[b] P = physical, B = behavioral, and M = metabolic; when more than one type is listed, the first is primary and the next is secondary. NA = not applicable.
[c] "–" indicates that the parameter is dimensionless.
[d] Value for this parameter will appear only if more than one room is selected in the "number of rooms" parameter.
[e] Value for this parameter will not appear if the selected source type is a point source.
[f] Value for this parameter will appear only if the selected source type is other than a volume source.
[g] Value for this parameter will appear only if at least one of the selected radionuclides is a radon precursor.
[h] The tritium evaporation model implemented in the RESRAD-BUILD code was adapted from the land farming model developed by Thibodeaux and Hwang (1982) to consider evaporation of hydrocarbons from contaminated soils.

Table A-6 Parameters and Their Default Values Used in RESRAD-BUILD V3.5 (cont.)

Parameter Name	Pathways Used	Unit	Default Value	Code-Accepted Values[a]	Type[b]	Reference	Description
Receptor Parameters (cont.)							
Receptor indirect ingestion rate	Ingestion	m^2/h	0.0001	>0	B	Yu et al., 2003	The rate at which an individual ingests deposited dust after it has transferred to hands, foods, or other items at each receptor location. This parameter is used in one of two ingestion pathways. The other pathway is direct ingestion of the contaminated material. The dose from indirect ingestion could be 0 if the ingestion rate is 0 or the deposition velocity is 0. Unlike the direct ingestion rate, the dose from this pathway might be nonzero when the source of contamination and the receptor points are in different rooms.
Source Parameters							
Number of sources	All	–	1	1–10	P	Yu et al., 2003	The number of sources at different locations, or of different geometrical, physical, and radiological characteristics of sources entered. Each source can have up to 10 radionuclides.

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[b] P = physical, B = behavioral, and M = metabolic; when more than one type is listed, the first is primary and the next is secondary. NA = not applicable.
[c] "–" indicates that the parameter is dimensionless.
[d] Value for this parameter will appear only if more than one room is selected in the "number of rooms" parameter.
[e] Value for this parameter will not appear if the selected source type is a point source.
[f] Value for this parameter will appear only if the selected source type is other than a volume source.
[g] Value for this parameter will appear only if at least one of the selected radionuclides is a radon precursor.
[h] The tritium evaporation model implemented in the RESRAD-BUILD code was adapted from the land farming model developed by Thibodeaux and Hwang (1982) to consider evaporation of hydrocarbons from contaminated soils.

Table A-6 Parameters and Their Default Values Used in RESRAD-BUILD V3.5 (cont.)

Parameter Name	Pathways Used	Unit	Default Value	Code-Accepted Values[a]	Type[b]	Reference	Description
Source Parameters (cont.)							
Source type	All	–	Volume	Point, line, area, volume	P	Yu et al., 2003	This could be one of four source types – point, line, area, or volume. Different assumptions and input parameters are required for the different types of sources. The user has a choice between circular, the default, and rectangular exposed area with some finite depth perpendicular to this area. Details of the five different regions and contamination need to be specified. The area source has a circular or rectangular exposed area with no thickness. There is a distinction between the volume type and the other sources in the air quality model. The injection and radon release models are different.
Source room	All except direct external	–	1	1, 2, 3	P	Yu et al., 2003	It could be one of up to a maximum of three rooms allowed in which each source must be located. It is the primary room location of the contamination source.

[a] Code-accepted values are not provided for nuclide-specific parameters.
[b] P = physical, B = behavioral, and M = metabolic; when more than one type is listed, the first is primary and the next is secondary. NA = not applicable.
[c] "–" indicates that the parameter is dimensionless.
[d] Value for this parameter will appear only if more than one room is selected in the "number of rooms" parameter.
[e] Value for this parameter will not appear if the selected source type is a point source.
[f] Value for this parameter will appear only if the selected source type is other than a volume source.
[g] Value for this parameter will appear only if at least one of the selected radionuclides is a radon precursor.
[h] The tritium evaporation model implemented in the RESRAD-BUILD code was adapted from the land farming model developed by Thibodeaux and Hwang (1982) to consider evaporation of hydrocarbons from contaminated soils.

Table A-6 Parameters and Their Default Values Used in RESRAD-BUILD V3.5 (cont.)

Parameter Name	Pathways Used	Unit	Default Value	Code-Accepted Values[a]	Type[b]	Reference	Description
Source Parameters (cont.)							
Source direction	Direct external	–	X direction	X, Y, Z	P	Yu et al., 2003	The direction of a source relative to the three axes. For the volume and area sources, it is the direction perpen-dicular to the exposed area. For the line source, it is the direction of the line. No direction required for point source. The source direction is used for external dose calculations only, and it determines the geometry of the source and receptor.
Source location	Direct external	–	0, 0, 0	Unlimited	P	Yu et al., 2003	The geometric coordinates to define the location of the source center in 3D space relative to the origin.
Details for Source							
Geometry	All	–	Circular	Circular/Rectangular	P	Yu et al., 2003	For volume and area sources user can select circular or rectangular geometry

[a] Code-accepted values are not provided for nuclide-specific parameters.
[b] P = physical, B = behavioral, and M = metabolic; when more than one type is listed, the first is primary and the next is secondary. NA = not applicable.
[c] "–" indicates that the parameter is dimensionless.
[d] Value for this parameter will appear only if more than one room is selected in the "number of rooms" parameter.
[e] Value for this parameter will not appear if the selected source type is a point source.
[f] Value for this parameter will appear only if the selected source type is other than a volume source.
[g] Value for this parameter will appear only if at least one of the selected radionuclides is a radon precursor.
[h] The tritium evaporation model implemented in the RESRAD-BUILD code was adapted from the land farming model developed by Thibodeaux and Hwang (1982) to consider evaporation of hydrocarbons from contaminated soils.

Table A-6 Parameters and Their Default Values Used in RESRAD-BUILD V3.5 (cont.)

Parameter Name	Pathways Used	Unit	Default Value	Code-Accepted Values[a]	Type[b]	Reference	Description
Source Parameters (cont.)							
Details for Source							
Source area for circular source	All	m or m^2	36[e]	> 0	P	Yu et al., 2003	This is the input for a circular source and also is calculated for a rectangular source. The measure of the extent of contamination from the center point of the source; it is assumed that the contamination is distributed evenly along these dimensions.
Length along one direction for rectangular source	All	–	0	> 0	P	Yu et al., 2003	Defines the rectangular source and used in calculating area.
Width along other direction for rectangular source	All	–	0	> 0	P	Yu et al., 2003	Defines the rectangular source and used in calculating area.
Air release fraction	All except direct external	–	0.1	0–1	B	Yu et al., 2003	The amount of contaminated material removed from the source that is in the respirable particulate range. It is assumed that the remainder of the material is removed immediately from the site.

[a] Code-accepted values are not provided for nuclide-specific parameters.
[b] P = physical, B = behavioral, and M = metabolic; when more than one type is listed, the first is primary and the next is secondary. NA = not applicable.
[c] "–" indicates that the parameter is dimensionless.
[d] Value for this parameter will appear only if more than one room is selected in the "number of rooms" parameter.
[e] Value for this parameter will not appear if the selected source type is a point source.
[f] Value for this parameter will appear only if the selected source type is other than a volume source.
[g] Value for this parameter will appear only if at least one of the selected radionuclides is a radon precursor.
[h] The tritium evaporation model implemented in the RESRAD-BUILD code was adapted from the land farming model developed by Thibodeaux and Hwang (1982) to consider evaporation of hydrocarbons from contaminated soils.

Table A-6 Parameters and Their Default Values Used in RESRAD-BUILD V3.5 (cont.)

Parameter Name	Pathways Used	Unit	Default Value	Code-Accepted Values[a]	Type[b]	Reference	Description
Source Parameters (cont.)							
Details for Source							
Direct ingestion rate	Ingestion	g/h (volume) and 1/h (area, line, point)	0	≥ 0	B	Yu et al., 2003	The incidental ingestion rate of contaminated material directly from the source by any receptor in the room. For a volume source, each receptor will ingest the source at a rate determined by the product of the ingestion rate and the amount of contamination in the source at that time. For a point, line, or area source, each receptor will ingest the source at a rate determined by the product of the ingestion rate, the removable fraction, and the amount of contamination in the source at that time.
Removable fraction	All	-	0.5[f]	0–1	P, B	Yu et al., 2003	The fraction of a point, line, or area source that is subject to removal. This fraction of the source will be linearly removed between time 0 and time for source removal.

[a] Code-accepted values are not provided for nuclide-specific parameters.
[b] P = physical, B = behavioral, and M = metabolic; when more than one type is listed, the first is primary and the next is secondary. NA = not applicable.
[c] "–" indicates that the parameter is dimensionless.
[d] Value for this parameter will appear only if more than one room is selected in the "number of rooms" parameter.
[e] Value for this parameter will not appear if the selected source type is a point source.
[f] Value for this parameter will appear only if the selected source type is other than a volume source.
[g] Value for this parameter will appear only if at least one of the selected radionuclides is a radon precursor.
[h] The tritium evaporation model implemented in the RESRAD-BUILD code was adapted from the land farming model developed by Thibodeaux and Hwang (1982) to consider evaporation of hydrocarbons from contaminated soils.

Table A-6 Parameters and Their Default Values Used in RESRAD-BUILD V3.5 (cont.)

Parameter Name	Pathways Used	Unit	Default Value	Code-Accepted Values[a]	Type[b]	Reference	Description
Source Parameters (cont.)							
Details for Source							
Time for source removal or source lifetime	All	d	365	>0	P, B	Yu et al., 2003	The time period during which the removable fraction of an area, line, or point source linearly erodes. If the source is fixed nothing will erode; the removable fraction should be set to 0, and the source lifetime would be immaterial.
Radon release fraction	Radon	–	0.1[g]	0–1	P, B	Yu et al., 2003	The fraction of the total amount of radon produced by radium decay that escapes the surface of a contaminated material and is released to air for point, line, or area source.
Radionuclide concentration	All	pCi/g pCi/m^2 pCi/m pCi	1 (Cobalt-60)	> 0	P	Yu et al., 2003	The activity (for a point source) or activity concentration of radionuclides distributed in a source. The units of measure depend on the type of source (volume: pCi/g; area: pCi/m^2; line: pCi/m; point: pCi).

[a] Code-accepted values are not provided for nuclide-specific parameters.
[b] P = physical, B = behavioral, and M = metabolic; when more than one type is listed, the first is primary and the next is secondary. NA = not applicable.
[c] "–" indicates that the parameter is dimensionless.
[d] Value for this parameter will appear only if more than one room is selected in the "number of rooms" parameter.
[e] Value for this parameter will not appear if the selected source type is a point source.
[f] Value for this parameter will appear only if the selected source type is other than a volume source.
[g] Value for this parameter will appear only if at least one of the selected radionuclides is a radon precursor.
[h] The tritium evaporation model implemented in the RESRAD-BUILD code was adapted from the land farming model developed by Thibodeaux and Hwang (1982) to consider evaporation of hydrocarbons from contaminated soils.

Table A-6 Parameters and Their Default Values Used in RESRAD-BUILD V3.5 (cont.)

Parameter Name	Pathways Used	Unit	Default Value	Code-Accepted Values[a]	Type[b]	Reference	Description
Source Parameters							
Details for Source							
Number of wall regions in volume source	All	–	1	1, 2, 3, 4, 5	P	Yu et al., 2003	The number of distinct layers in a volume source. The contamination is within these regions and the thickness of the volume source is the sum of the thickness of these regions.
Number of wall regions in volume source	All	–	1	1, 2, 3, 4, 5	P	Yu et al., 2003	The number of distinct layers in a volume source. The contamination is within these regions and the thickness of the volume source is the sum of the thickness of these regions.
Material type	Direct external	–	Concrete	Concrete, water, aluminum, iron, copper, tungsten, lead, uranium	P	Yu et al., 2003	The code can handle concrete, water, aluminum, iron, copper, tungsten, lead, or uranium as source material.
Layer region parameters							
Contaminated region-volume source	All	–	1	1, 2, 3, 4, 5	P	Yu et al., 2003	One of up to five layers in an idealized volume source that contains radionuclide contamination.
Source thickness, volume source	All	cm	15	> 0	P	Yu et al., 2003	The thickness of each layer in an idealized volume source.

[a] Code-accepted values are not provided for nuclide-specific parameters.
[b] P = physical, B = behavioral, and M = metabolic; when more than one type is listed, the first is primary and the next is secondary. NA = not applicable.
[c] "–" indicates that the parameter is dimensionless.
[d] Value for this parameter will appear only if more than one room is selected in the "number of rooms" parameter.
[e] Value for this parameter will not appear if the selected source type is a point source.
[f] Value for this parameter will appear only if the selected source type is other than a volume source.
[g] Value for this parameter will appear only if at least one of the selected radionuclides is a radon precursor.
[h] The tritium evaporation model implemented in the RESRAD-BUILD code was adapted from the land farming model developed by Thibodeaux and Hwang (1982) to consider evaporation of hydrocarbons from contaminated soils.

Table A-6 Parameters and Their Default Values Used in RESRAD-BUILD V3.5 (cont.)

Parameter Name	Pathways Used	Unit	Default Value	Code-Accepted Values[a]	Type[b]	Reference	Description
Source Parameters (cont.)							
Layer region parameters							
Source density, volume source	Direct external	g/cm^3	2.4	≥ 0	P	Yu et al., 2003	The effective density of each layer in an idealized volume source.
Source erosion rate, volume source	All	cm/d	2.40E-08	≥ 0	P, B	Yu et al., 2003	The erosion rate of each layer in an idealized volume source when each layer is exposed.
Source porosity	Radon	–	0.1[g]	0–1	P	Yu et al., 2003	The ratio of the pore volume to the total volume. Although 0 value is accepted by the code for porosity, it will give no results.
Radon effective diffusion coefficient	Radon	m^2/s	2E-5[g]	≥ 0	P	Yu et al., 2003	The diffusion coefficient of radon source materials.
Radon emanation coefficient	Radon	–	0.2[g]	0–1	P	Yu et al., 2003	The fraction of the total amount of radon produced by radium decay that escapes the contaminated material and gets into the pores of the medium.
Shielding Parameters							
Shielding thickness	Direct external	cm	0	≥ 0	P, B	Yu et al., 2003	The effective (line-of-sight) thickness of shielding between a receptor and a source.

[a] Code-accepted values are not provided for nuclide-specific parameters.
[b] P = physical, B = behavioral, and M = metabolic; when more than one type is listed, the first is primary and the next is secondary. NA = not applicable.
[c] "–" indicates that the parameter is dimensionless.
[d] Value for this parameter will appear only if more than one room is selected in the "number of rooms" parameter.
[e] Value for this parameter will not appear if the selected source type is a point source.
[f] Value for this parameter will appear only if the selected source type is other than a volume source.
[g] Value for this parameter will appear only if at least one of the selected radionuclides is a radon precursor.
[h] The tritium evaporation model implemented in the RESRAD-BUILD code was adapted from the land farming model developed by Thibodeaux and Hwang (1982) to consider evaporation of hydrocarbons from contaminated soils.

Table A-6 Parameters and Their Default Values Used in RESRAD-BUILD V3.5 (cont.)

Parameter Name	Pathways Used	Unit	Default Value	Code-Accepted Values[a]	Type[b]	Reference	Description
Shielding Parameters (cont.)							
Shielding thickness	Direct external	cm	0	≥ 0	P, B	Yu et al., 2003	The effective (line-of-sight) thickness of shielding between a receptor and a source.
Shielding density	Direct external	g/cm^3	2.4	> 0	P	Yu et al., 2003	The effective density of shielding between a receptor and a source.
Shielding material	Direct external	–	Concrete	Concrete, water, aluminum, iron, copper, tungsten, lead, uranium	P	Yu et al., 2003	The type of material used in the shield between the receptor and the source. The code can handle concrete, water, aluminum, iron, copper, tungsten, lead, or uranium.
Tritium parameters for volume source							
Area	Tritium volume source	m^2	36	> 0	P	Yu et al., 2003	The measure of the area of contamination from the center point of the source.

[a] Code-accepted values are not provided for nuclide-specific parameters.
[b] P = physical, B = behavioral, and M = metabolic; when more than one type is listed, the first is primary and the next is secondary. NA = not applicable.
[c] "–" indicates that the parameter is dimensionless.
[d] Value for this parameter will appear only if more than one room is selected in the "number of rooms" parameter.
[e] Value for this parameter will not appear if the selected source type is a point source.
[f] Value for this parameter will appear only if the selected source type is other than a volume source.
[g] Value for this parameter will appear only if at least one of the selected radionuclides is a radon precursor.
[h] The tritium evaporation model implemented in the RESRAD-BUILD code was adapted from the land farming model developed by Thibodeaux and Hwang (1982) to consider evaporation of hydrocarbons from contaminated soils.

Table A-6 Parameters and Their Default Values Used in RESRAD-BUILD V3.5 (cont.)

Parameter Name	Pathways Used	Unit	Default Value	Code-Accepted Values[a]	Type[b]	Reference	Description
Tritium parameters for volume source (cont.)							
Dry zone thickness	Tritium volume source	cm	0	≥ 0	P	Yu et al., 2003	RESRAD-BUILD has a specific model[h] to consider the volatilization of tritiated water (HTO) from the contaminated material. A contaminated layer with HTO can be located within the material. The dry zone thickness is the thickness between the uppermost plane of the contaminated zone and the surface of the material (or the interface of the material and the indoor atmosphere). As water molecules evaporate, tritium is released to the indoor air and results in potential radiation exposure. To estimate the release rate of tritium, the values of several additional parameters are required.

[a] Code-accepted values are not provided for nuclide-specific parameters.
[b] P = physical, B = behavioral, and M = metabolic; when more than one type is listed, the first is primary and the next is secondary. NA = not applicable.
[c] "–" indicates that the parameter is dimensionless.
[d] Value for this parameter will appear only if more than one room is selected in the "number of rooms" parameter.
[e] Value for this parameter will not appear if the selected source type is a point source.
[f] Value for this parameter will appear only if the selected source type is other than a volume source.
[g] Value for this parameter will appear only if at least one of the selected radionuclides is a radon precursor.
[h] The tritium evaporation model implemented in the RESRAD-BUILD code was adapted from the land farming model developed by Thibodeaux and Hwang (1982) to consider evaporation of hydrocarbons from contaminated soils.

Table A-6 Parameters and Their Default Values Used in RESRAD-BUILD V3.5 (cont.)

Parameter Name	Pathways Used	Unit	Default Value	Code-Accepted Values[a]	Type[b]	Reference	Description
Tritium parameters for volume source (cont.)							
Wet + dry zone thickness	Tritium volume source	cm	10	> Dry zone thickness	P	Yu et al., 2003	The thickness between the surface of the contaminated material and the bottom of the contaminated zone.
Volumetric water content	Tritium volume source	–	0.03	> 0–1	P	Yu et al., 2003	The volume of water per unit volume of the porous material. This value should be less than the total porosity of the solid material.
Water fraction available for evaporation	Tritium volume source	–	1	0–1	P	Yu et al., 2003	The fraction of the amount of water in the contaminated zone that will volatize to the total amount of water in the contaminated zone. This parameter is used to account for potential binding between water molecules and the solid matrix of the contaminated zone, which prohibits volatilization of water molecules.
Total porosity of contaminated material	Tritium volume source	–	0.1	> 0–1	P	Yu et al., 2003	The ratio of the pore volume to the total volume. Although 0 value is accepted by the code for porosity, it will give no results.
Density of material	Tritium volume source	g/cm^3	2.4	≥ 0	P	Yu et al., 2003	The effective density of an idealized volume source.

[a] Code-accepted values are not provided for nuclide-specific parameters.
[b] P = physical, B = behavioral, and M = metabolic; when more than one type is listed, the first is primary and the next is secondary. NA = not applicable.
[c] "–" indicates that the parameter is dimensionless.
[d] Value for this parameter will appear only if more than one room is selected in the "number of rooms" parameter.
[e] Value for this parameter will not appear if the selected source type is a point source.
[f] Value for this parameter will appear only if the selected source type is other than a volume source.
[g] Value for this parameter will appear only if at least one of the selected radionuclides is a radon precursor.
[h] The tritium evaporation model implemented in the RESRAD-BUILD code was adapted from the land farming model developed by Thibodeaux and Hwang (1982) to consider evaporation of hydrocarbons from contaminated soils.

Table A-6 Parameters and Their Default Values Used in RESRAD-BUILD V3.5 (cont.)

Parameter Name	Pathways Used	Unit	Default Value	Code-Accepted Values[a]	Type[b]	Reference	Description
Tritium parameters for volume source (cont.)							
Humidity	Tritium volume source	g/m^3	8	≥ 0	P, B	Yu et al., 2003	The average humidity in the building. The value is dependent on the air conditioning and ventilation in the building.
Erosion rate	Tritium volume source	cm/d	2.40E-08	≥ 0	P, B	Yu et al., 2003	The erosion rate of tritium volume source.
Direct ingestion rate	Tritium volume source	g/h	0	≥ 0	B	Yu et al., 2003	The incidental ingestion rate of removable contaminated material directly from the source by any receptor in the room. Each receptor will ingest the source at a rate determined by the product of the ingestion rate, the removable fraction, and the amount of contamination in the source at that time.
Air release fraction	Tritium volume source	–	0.1	0–1	B	Yu et al., 2003	The amount of contaminated material removed from the source that is in the respirable particulate range. It is assumed that the remainder of the material is removed immediately from the site.

[a] Code-accepted values are not provided for nuclide-specific parameters.
[b] P = physical, B = behavioral, and M = metabolic; when more than one type is listed, the first is primary and the next is secondary. NA = not applicable.
[c] "–" indicates that the parameter is dimensionless.
[d] Value for this parameter will appear only if more than one room is selected in the "number of rooms" parameter.
[e] Value for this parameter will not appear if the selected source type is a point source.
[f] Value for this parameter will appear only if the selected source type is other than a volume source.
[g] Value for this parameter will appear only if at least one of the selected radionuclides is a radon precursor.
[h] The tritium evaporation model implemented in the RESRAD-BUILD code was adapted from the land farming model developed by Thibodeaux and Hwang (1982) to consider evaporation of hydrocarbons from contaminated soils.

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APPENDIX B PROBABILISTIC ANALYSIS

Probabilistic analysis was conducted to evaluate the influence of input parameters on radiation exposures associated with several common exposure scenarios involving a few selected radionuclides, including C-14, Co-60, Cs-137, H-3, I-129, Np-237, Pu-239, Ra-226, Ra-228, Sr-90, Tc-99, and U-238. The selected list include radionuclides that have special models (C-14, H-3, Ra-226, and Ra-228), strong gamma emitters (Co-60 and Cs-137), strong beta emitter (Sr-90), and radionuclides (I-129, Np-237, Pu-239, Tc-99, and U-238) requested by NRC (Private Communication 2016). RESRAD-ONSITE code version 7.2 was used to evaluate the sensitivity of the results to various RESRAD-ONSITE parameters with respect to a resident farmer scenario, and RESRAD-BUILD code version 3.5 was used to evaluate sensitivity of the results to various RESRAD-BUILD parameters with respect to a building occupancy scenario. RESRAD-OFFSITE code version 4.0 was used to evaluate influence of input parameters related to the transport of radionuclides in water and in the air, leading to radiation exposures to Offsite Resident scenario via Water Transport and Offsite Resident via Air Transport scenarios. The probabilistic analysis quantifies the uncertainty in radiation dose results caused by the uncertainty in the input parameter values.

B.1 Resident Farmer Scenario

The purpose of this analysis was to illustrate the use of the probabilistic RESRAD-ONSITE code to simulate the use of a decontaminated property for residential and farming activities as described in NUREG/CR-5512 (Kennedy and Strenge 1992) and NUREG-1757 (NRC 2006). The probabilistic analysis was performed to identify parameters that have significant effect on peak total dose. The probabilistic analysis was also used to illustrate how a data template file of updated input parameters for deterministic analysis may be constructed to transition from the probabilistic dose analysis to a site-specific deterministic analysis.

B.1.1 Selection of Input Parameters for Resident Farmer Scenario

In a probabilistic analysis, behavioral parameters were kept at a fixed value (obtained from DandD, Table 6.87 in NUREG/CR-5512 Volume 3) and physical parameters were assigned a statistical distribution. Table B-1 lists DandD behavioral parameter values with comparison to the RESRAD-ONSITE default values. For physical parameters, the statistical distributions assigned were those developed in 2000 as documented in NUREG/CR-6697 (Yu et al. 2000), except for the distribution coefficient (K_d), plant, meat, and milk transfer factors, and fish bioaccumulation factor. For these parameters, new statistical distributions were developed, based on new information collected and documented in the updated data collection handbook published in 2015 (Yu et al. 2015). Table B-2 lists the input parameters of the RESRAD-ONSITE code, their base value used in the deterministic calculations, and their statistical distribution (including the distribution function and the associated distribution parameters) used in the probabilistic calculations. For physical parameters, for which there was no parameter distribution developed in 2000, professional judgement was used in assigning parameter distribution for this sensitivity analysis. Radionuclide or element specific input parameters are listed in separate tables. Table B-3, Table B-4, Table B-5, Table B-6, Table B-7, and Table B-8 list point values and statistical distributions for the plant transfer factor, meat transfer factor, milk transfer factor, fish bioaccumulation factor, crustacean bioaccumulation factor, and K_d, respectively. Some input parameters are correlated (e.g., density and porosity are negatively correlated); the correlation coefficients used in the analysis are listed in Table B-9 (Yu et al. 2000).

Table B-1 DandD Behavioral Parameter Values with Comparison to the RESRAD-ONSITE Default Parameter Values

Parameters	DandD	RESRAD-ONSITE	Remarks
Irrigation rate	1.20 l/m^2*day (0.1125 m/y)	0.2 m/y	Irrigation rate and well pumping rate will only affect the calculated total dose when water-dependent pathways contribute to total dose.
Well pumping rate	118,000 l/y (118 m^3/y)	250 m^3/y	
Indoor breathing rate	0.9 m^3/h		RESRAD-ONSITE uses one yearly average breathing rate compared with three activity-specific breathing rates specified in DandD. The inhalation rate of 8578 m^3/y is calculated by using the default inhalation rates and time fractions spent in different activities and normalizing with the total time spent in those activities. The calculated inhalation rate is ~2 percent higher and would increase the inhalation pathway doses accordingly.
Outdoor breathing rate	1.4 m^3/h		
Gardening breathing rate	1.7 m^3/h		
Inhalation rate	8578 m^3/y	8400 m^3/y	
Time indoor	240 d/y (0.657 y)	0.5 y	Total time spent at site in DandD is 0.775 compared with 0.75 in RESRAD-ONSITE. This change will affect the pathway doses differently for different pathways. RESRAD-ONSITE assumes more time spent outdoors and DandD assumes more time spent indoors. When the receptor is outdoors, no external radiation shielding is applied; therefore, external pathway doses would decrease if DandD defaults are used. For the inhalation pathway, shielding is applied when the receptor is indoors; this would decrease the radiation dose. However, the soil ingestion pathway dose would increase if more time is spent on site (0.775 compared with 0.75).
Time outdoor	40.2 d/y (0.11 y)	0.25 y	

Table B-1 DandD Behavioral Parameter Values with Comparison to the RESRAD-ONSITE Default Parameter Values (cont.)

Parameters	DandD	RESRAD-ONSITE	Remarks
Time gardening	2.92 d/y (0.008 y)	0	RESRAD-ONSITE does not include separate time assigned for gardening activities.
Fruit, vegetables, and grain consumption	52.8 + 44.6 + 14.4 = 111.8 kg/y	160 kg/y	Lower DandD consumption rate (fruit, vegetable, grain, and leafy vegetable) would decrease the plant ingestion pathway dose. (RESRAD-ONSITE uses the same plant transfer factors for leafy and non-leafy vegetables.)
Leafy vegetable consumption	21.4 kg/y	14 kg/y	
Milk consumption	233 l/y	92 l/y	DandD milk consumption is 2.5 times of RESRAD-ONSITE value and will increase the milk ingestion pathway dose accordingly. Milk ingestion contributes about ~8 percent of the total dose; therefore, this change (increasing dose 2.5 times for milk ingestion) could make ingestion a dominant pathway.
Meat and poultry consumption	39.8 + 25.3 = 65.1 kg/y	63 kg/y	DandD value for meat and poultry consumption is 3 percent higher than RESRAD-ONSITE value.
Fish consumption	20.6 kg/y	5.4 kg/y	Higher DandD fish consumption will increase the fish ingestion pathway dose.
Other seafood consumption	NA	0.9 kg/y	The DandD code does not consider other seafood consumption.
Soil ingestion rate	0.05 g/d (18.25 g/y)	36.5 g/y	Lower soil ingestion rate in DandD will decrease the soil ingestion pathway dose.
Drinking water intake	1.31 l/d (478.5 l/y)	510 l/y	Lower water intake in DandD will decrease the water ingestion pathway dose.

Table B-2 Base Values and Statistical Distributions of Input Parameters Used in the RESRAD-ONSITE Code for the Resident Farmer Scenario Analysis

Input parameter	Units	Type[b]	Base value for deterministic calculation	Source	Probabilistic analysis[a]					Description
					Distribution	Parameter 1	Parameter 2	Parameter 3	Parameter 4	
Initial Nuclide Concentration in Soil	pCi/g	P	1.00E+00	Base value for deterministic calculation corresponds to the default value used in the DandD code.	None	NR[c]	NR	NR	NR	Average radionuclide concentration in the contaminated zone. Radionuclides analyzed H-3, C-14, Co-60, Cs-137, Sr-90, I-129, Np-237, Pu-239, Ra-226, Ra-228, Tc-99, and U-238
Plant transfer factors	pCi/g plant per pCi/g soil	P	Table B-3	Base value for deterministic calculation corresponds to the median value from the Statistical distribution. Statistical distributions from the updated data collection handbook published in 2015 (Yu et al. 2015) are used for probabilistic calculations.	for all truncated lognormal-n	Table B-3	Table B-3	Table B-3	Table B-3	The ratio of radionuclide concentration in edible portions of the plant at harvest time to the dry soil radionuclide concentration. It is assumed that the same plant transfer factors can be used for leafy and non-leafy vegetables. The code has element specific values and the user is allowed to change these values.
Meat transfer factor	pCi/kg per pCi/d	P	Table B-4	Same as for plant transfer factors.	for all truncated lognormal-n	Table B-4	Table B-4	Table B-4	Table B-4	The ratio of radionuclide concentration in beef to the daily intake of the same radionuclide in livestock feed or water. The code has element specific values and the user is allowed to change these values.
Milk transfer factor	pCi/L per pCi/d	P	Table B-5	Same as for plant transfer factors.	for all truncated lognormal-n	Table B-5	Table B-5	Table B-5	Table B-5	The ratio of radionuclide concentration in milk to the daily intake of the same radionuclide in the livestock feed or water. The code has element specific values and the user is allowed to change these values.
Fish bioaccumulation factor	pCi/kg per pCi/L	P	Table B-6	Same as for plant transfer factors.	for all lognormal-n	Table B-6	Table B-6	Table B-6	Table B-6	The ratio of radionuclide concentration in the aquatic food to the concentration of the same radionuclide in water. The code has element specific aquatic bioaccumulation factors for fish and crustacea and mollusks and the user is allowed to change these values.
Crustacea bioaccumulation factor	pCi/kg per pCi/L	P	Table B-7	Base value for deterministic calculation corresponds to the suggested value from the updated data collection handbook published in 2015 (Yu et al. 2015). No statistical distributions are assigned.	No	NA[d]	NA	NA	NA	The ratio of radionuclide concentration in the aquatic food to the concentration of the same radionuclide in water. The code has element specific aquatic bioaccumulation factors for fish, crustaceans, and mollusks and the user is allowed to change these values.

[a] For truncated lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution, parameter 3 = lower quantile, and parameter 4 = upper quantile; for lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution; for triangular distribution, parameter 1 = minimum, parameter 2 = mode or most likely, and parameter 3 = maximum; for truncated normal distribution, parameter 1 = mean, parameter 2 = standard deviation, parameter 3 = lower quantile, and parameter 4 = upper quantile; for bounded lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution, parameter 3 = minimum value, and parameter 4 = maximum value; for uniform distribution, parameter 1 = minimum, and parameter 2 = maximum; for continuous linear distribution, number of points, value of points, and cdf of points; for continuous logarithmic distribution, number of points, value of points, and cdf of points.

[b] P = physical, B= behavioral, and M = metabolic parameter.

[c] NR = not required.

[d] NA = not applicable.

Note: Density, porosity, and effective porosity are correlated. Correlations are used for uranium isotope Kd values in different zones.

Table B-2 Base Values and Statistical Distributions of Input Parameters Used in the RESRAD-ONSITE Code for the Resident Farmer Scenario Analysis (cont.)

Input Parameter	Units	Type[b]	Base value for deterministic calculation	Source	Probabilistic Analysis[a]					Description
					Distribution	Parameter 1	Parameter 2	Parameter 3	Parameter 4	
Transport Factors										
Distribution coefficients in contaminated, unsaturated, and saturated zones	cm^3/g	P	Table B-8	Selected values are from Table 2.13.9 in the updated data collection handbook (Yu et al. 2015). The base values are the values for the generic soil type. The Statistical distributions are for the generic soil type.	for all truncated lognormal-n	Table B-8	Table B-8	Table B-8	Table B-8	Site-specific values should be used everywhere for each radionuclide. Default values and distributions are provided by the code for most radionuclides. However, these values should be used with care because distribution coefficients can vary over many orders of magnitude.
Number of unsaturated zones	none	P	1		no	NR	NR	NR	NR	An unsaturated zone is defined as a horizontal uncontaminated layer located between the contaminated zone and the aquifer. The RESRAD-ONSITE code allows a maximum of five unsaturated zones.
Time since material placement	years	P	0.00E+00		no	NR	NR	NR	NR	The duration between the placement of radioactive material onsite and the performance of a radiological survey. A nonzero value for this parameter is necessary to activate the groundwater concentration input box. The non-zero value of this parameter is used along with groundwater concentration to calculate the water/soil concentration ratio and effective distribution coefficient.
Groundwater concentration	pCi/L	P	NR		no	NR	NR	NR	NR	It is the groundwater concentration of a principal radionuclide measured at the same time as the soil concentration. Groundwater concentration can be input only if time since placement of material is >0.
Solubility limit	mol/L	P	NR		no	NR	NR	NR	NR	The solubility limit provides an additional option for calculating the distribution coefficient in the code. The solubility limit serves as an upper bound on the amount of radionuclide released from the soil particles.

[a] For truncated lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution, parameter 3 = lower quantile, and parameter 4 = upper quantile; for lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution; for triangular distribution, parameter 1 = minimum, parameter 2 = mode or most likely, and parameter 3 = maximum; for truncated normal distribution, parameter 1 = mean, parameter 2 = standard deviation, parameter 3 = lower quantile, and parameter 4 = upper quantile; for bounded lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution, parameter 3 = minimum value, and parameter 4 = maximum value; for uniform distribution, parameter 1 = minimum, and parameter 2 = maximum; for continuous linear distribution, number of points, value of points, and cdf of points; for continuous logarithmic distribution, number of points, value of points, and cdf of points.

[b] P = physical, B= behavioral, and M = metabolic parameter.

[c] NR = not required.

[d] NA = not applicable.

Note: Density, porosity, and effective porosity are correlated. Correlations are used for uranium isotope Kd values in different zones.

Table B-2 Base Values and Statistical Distributions of Input Parameters Used in the RESRAD-ONSITE Code for the Resident Farmer Scenario Analysis (cont.)

Input Parameter	Units	Type[b]	Base value for deterministic calculation	Source	Probabilistic Analysis[a]					Description
					Distribution	Parameter 1	Parameter 2	Parameter 3	Parameter 4	
Transport Factors (cont.)										
Leach rate	/year	P	NR		no	NR	NR	NR	NR	It is the fraction of the available radionuclide leached from the contaminated zone per unit of time. Radionuclide leach rates should be used if known. The nonzero leach rate is used to calculate the leaching of the radionuclide from the contaminated zone and to derive the water/soil concentration ratio and distribution coefficient. If the derived distribution coefficient is greater than zero, the input distribution coefficient would be replaced by the derived values.
Use plant soil ratio	check box	NA	No		No	NR	NR	NR	NR	The code allows distribution coefficients to be calculated from the plant root uptake factors (plant/soil concentration ratio). This option becomes active if the plant/soil ratio box is checked.
Calculation Parameters										
Basic radiation dose limit	mrem/yr	NA	2.50E+01		No	NR	NR	NR	NR	The annual radiation dose limit in mrem/y, used to derive all site-specific guidelines.
Calculation times	years	P	1,3,10,30,100, 300,1000		No	NR	NR	NR	NR	The times in years following the radiological survey for which tabular values for single-radionuclide soil guidelines and mixture sums are obtained. The code calculates dose at time zero and up to nine user specified times.

[a] For truncated lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution, parameter 3 = lower quantile, and parameter 4 = upper quantile; for lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution; for triangular distribution, parameter 1 = minimum, parameter 2 = mode or most likely, and parameter 3 = maximum; for truncated normal distribution, parameter 1 = mean, parameter 2 = standard deviation, parameter 3 = lower quantile, and parameter 4 = upper quantile; for bounded lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution, parameter 3 = minimum value, and parameter 4 = maximum value; for uniform distribution, parameter 1 = minimum, and parameter 2 = maximum; for continuous linear distribution, number of points, value of points, and cdf of points; for continuous logarithmic distribution, number of points, value of points, and cdf of points.

[b] P = physical, B= behavioral, and M = metabolic parameter.

[c] NR = not required.

[d] NA = not applicable.

Note: Density, porosity, and effective porosity are correlated. Correlations are used for uranium isotope Kd values in different zones.

Table B-2 Base Values and Statistical Distributions of Input Parameters Used in the RESRAD-ONSITE Code for the Resident Farmer Scenario Analysis (cont.)

Input Parameter	Units	Type[b]	Base value for deterministic calculation	Source	Probabilistic Analysis[a]					Description
					Distribution	Parameter 1	Parameter 2	Parameter 3	Parameter 4	
Calculation Parameters										
Basic radiation dose limit	mrem/yr	NA	2.50E+01		No	NR	NR	NR	NR	The annual radiation dose limit in mrem/y, used to derive all site-specific guidelines.
Calculation times	years	P	1,3,10,30,100, 300,1000		No	NR	NR	NR	NR	The times in years following the radiological survey for which tabular values for single-radionuclide soil guidelines and mixture sums are obtained. The code calculates dose at time zero and up to nine user specified times.
Contaminated Zone Parameters										
Thickness of contaminated zone	m	P	1.50E-01	For deterministic calculation, the base value is the default used in DandD (Table 6.87 in NUREG/CR-5512 Volume 3). It is assumed that this parameter has a triangular distribution with the mode corresponding to the base value. The minimum and maximum values of the triangular distribution were selected to observe change in radiation doses.	Triangular	1.50E-01	1.50E-01	4.00E+00	NR	The distance between the uppermost and lowermost soil samples that have radionuclide concentration clearly above background.
Area of contaminated zone	m^2	P	2.40E+03	For deterministic calculation, the base value is the default used in DandD (Table 6.87 in NUREG/CR-5512 Volume 3). It is assumed that this parameter has a triangular distribution with the mode corresponding to base value. The minimum and maximum values of the triangular distribution were selected to observe change in radiation doses.	Triangular	1.00E+02	2.40E+03	1.00E+04	NR	Total area of the site that is homogeneously contaminated.

[a] For truncated lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution, parameter 3 = lower quantile, and parameter 4 = upper quantile; for lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution; for triangular distribution, parameter 1 = minimum, parameter 2 = mode or most likely, and parameter 3 = maximum; for truncated normal distribution, parameter 1 = mean, parameter 2 = standard deviation, parameter 3 = lower quantile, and parameter 4 = upper quantile; for bounded lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution, parameter 3 = minimum value, and parameter 4 = maximum value; for uniform distribution, parameter 1 = minimum, and parameter 2 = maximum; for continuous linear distribution, number of points, value of points, and cdf of points; for continuous logarithmic distribution, number of points, value of points, and cdf of points.

[b] P = physical, B= behavioral, and M = metabolic parameter.

[c] NR = not required.

[d] NA = not applicable.

Note: Density, porosity, and effective porosity are correlated. Correlations are used for uranium isotope Kd values in different zones.

Table B-2 Base Values and Statistical Distributions of Input Parameters Used in the RESRAD-ONSITE Code for the Resident Farmer Scenario Analysis (cont.)

Input Parameter	Units	Type[b]	Base value for deterministic calculation	Source	Probabilistic Analysis[a]					Description
					Distribution	Parameter 1	Parameter 2	Parameter 3	Parameter 4	
Contaminated Zone Parameters (cont.)										
Length parallel to aquifer flow	m	P	4.90E+01	Base value and the minimum and maximum of the triangular distribution correspond to the square root of the "area of contaminated zone" parameter.	Triangular	1.00E+01	4.90E+01	1.00E+02	NR	The distance between two parallel lines perpendicular to the direction of aquifer flow, one at the up gradient edge of the contaminated zone and the other at the down gradient edge.
Cover and Contaminated Zone Hydrological Data										
Cover depth	m	P	0.00E+00	There is no cover on top of the contaminated zone.	NR	NR	NR	NR	NR	Distance from the ground surface to the contaminated zone.
Density of cover material	g/cm^3	P	NR	NR	NR	NR	NR	NR	NR	Bulk density of the cover material.
Cover erosion rate	m/yr	P, B	NR	NR	NR	NR	NR	NR	NR	The average volume of cover material that is removed per unit of ground surface area and per unit of time. Erosion rates can be estimated by means of universal soil loss equation.
Density of contaminated zone	g/cm^3	P	1.43E+00	For deterministic calculation, the base value is the default used in DandD. For probabilistic calculations, the statistical distribution is for generic soil type from NUREG/CR-6697.	Truncated normal	1.52E+00	2.30E-01	1.00E-03	9.99E-01	Bulk density of the contaminated zone.
Contaminated zone erosion rate	m/yr	P, B	1.90E-03	For deterministic calculation, the base value is the median from the statistical distribution. For probabilistic calculations, the statistical distribution is from NUREG/CR-6697.	Continuous logarithmic					The average volume of source material that is removed per unit of ground surface area and per unit of time.

[a] For truncated lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution, parameter 3 = lower quantile, and parameter 4 = upper quantile; for lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution; for triangular distribution, parameter 1 = minimum, parameter 2 = mode or most likely, and parameter 3 = maximum; for truncated normal distribution, parameter 1 = mean, parameter 2 = standard deviation, parameter 3 = lower quantile, and parameter 4 = upper quantile; for bounded lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution, parameter 3 = minimum value, and parameter 4 = maximum value; for uniform distribution, parameter 1 = minimum, and parameter 2 = maximum; for continuous linear distribution, number of points, value of points, and cdf of points; for continuous logarithmic distribution, number of points, value of points, and cdf of points.

[b] P = physical, B= behavioral, and M = metabolic parameter.

[c] NR = not required.

[d] NA = not applicable.

Note: Density, porosity, and effective porosity are correlated. Correlations are used for uranium isotope Kd values in different zones.

Table B-2 Base Values and Statistical Distributions of Input Parameters Used in the RESRAD-ONSITE Code for the Resident Farmer Scenario Analysis (cont.)

Input Parameter	Units	Type[b]	Base value for deterministic calculation	Source	Probabilistic Analysis[a]					Description
					Distribution	Parameter 1	Parameter 2	Parameter 3	Parameter 4	
Cover and Contaminated Zone Hydrological Data (cont.)										
Contaminated zone total porosity	none	P	4.60E-01	For deterministic calculation, the base value is the default used in DandD (Table 6.87 in NUREG/CR-5512 Volume 3). For probabilistic calculations, the statistical distribution is from NUREG/CR-6697 for generic soil type.	Truncated normal	4.30E-01	6.99E-02	1.00E-03	9.99E-01	Ratio of the pore volume to the total volume of the contaminated zone.
Contaminated zone field capacity	none	P	2.00E-01	For deterministic calculation, the base value is the default used in RESRAD-ONSITE. For probabilistic calculations, a triangular distribution with a mode corresponding to the base value is used. The minimum and maximum values were taken to be 1/2 and twice, respectively, of the base value to observe changes in radiation dose.	Triangular	1.00E-01	2.00E-01	4.00E-01	NR	Volumetric moisture content of soil at which (free) gravity drainage ceases. This is the amount of moisture that will be retained in a column of soil against the force of gravity.
Contaminated zone hydraulic conductivity	m/yr	P	1.00E+01	For deterministic calculation, the base value is the median from the statistical distribution. For probabilistic calculations, the statistical distribution is from NUREG/CR-6697 for generic soil type.	Bounded lognormal-n	2.30E+00	2.11E+00	4.00E-03	9.25E+03	The measure of the soil's ability to transmit water when submitted to a hydraulic gradient. The hydraulic conductivity depends on the soil grain size, the structure of the soil matrix, the type of soil fluid, and the relative amount of soil fluid (saturation) present in the soil matrix.
Contaminated zone b parameter	none	P	3.59	For deterministic calculation, the base value is the mean from the statistical distribution. For probabilistic calculations, the statistical distribution is from NUREG/CR-6697 for generic soil type.	Bounded lognormal-n	1.06E+00	6.60E-01	5.00E-01	3.00E+01	An empirical and dimensionless parameter that is used to evaluate the saturation ratio (or volumetric water saturation) of the soil according to a soil characteristic function called the conductivity function.

[a] For truncated lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution, parameter 3 = lower quantile, and parameter 4 = upper quantile; for lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution; for triangular distribution, parameter 1 = minimum, parameter 2 = mode or most likely, and parameter 3 = maximum; for truncated normal distribution, parameter 1 = mean, parameter 2 = standard deviation, parameter 3 = lower quantile, and parameter 4 = upper quantile; for bounded lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution, parameter 3 = minimum value, and parameter 4 = maximum value; for uniform distribution, parameter 1 = minimum, and parameter 2 = maximum; for continuous linear distribution, number of points, value of points, and cdf of points; for continuous logarithmic distribution, number of points, value of points, and cdf of points.

[b] P = physical, B= behavioral, and M = metabolic parameter.

[c] NR = not required.

[d] NA = not applicable.

Note: Density, porosity, and effective porosity are correlated. Correlations are used for uranium isotope Kd values in different zones.

Table B-2 Base Values and Statistical Distributions of Input Parameters Used in the RESRAD-ONSITE Code for the Resident Farmer Scenario Analysis (cont.)

Input Parameter	Units	Type[b]	Base value for deterministic calculation	Source	Probabilistic Analysis[a]					Description
					Distribution	Parameter 1	Parameter 2	Parameter 3	Parameter 4	
Cover and Contaminated Zone Hydrological Data (cont.)										
Humidity in air	g/m^3	P	7.24	For deterministic calculation, the base value is the median from the statistical distribution. For probabilistic calculations, the statistical distribution is from NUREG/CR-6697.	Truncated lognormal-n	1.98E+00	3.34E-01	1.00E-03	9.99E-01	Average absolute humidity in air. It is used in the tritium model to calculate tritium concentration in air.
Evapotranspiration coefficient	none	P	7.00E-01	For deterministic calculation, the base value is kept fixed at 0.7. The statistical distribution is from NUREG/CR-6697.	Uniform	5.00E-01	7.50E-01			The ratio of the total volume of water leaving the ground via evapotranspiration to the total volume of water available within the root zone of the soil during a fixed period of time.
Wind speed	m/s	P	4.20E+00	For deterministic calculation, the base value is the median from the statistical distribution. For probabilistic calculations, the statistical distribution is from NUREG/CR-6697.	Bounded lognormal-n	1.45E+00	2.42E-01	1.40E+00	1.30E+01	The overall average of the wind speed, measured near the ground.
Precipitation rate	m/yr	P	1.00E+00	For deterministic calculation, the base value is the RESRAD-ONSITE default value. For probabilistic calculations, a triangular distribution with a mode corresponding to the base value is used. The maximum of the triangular distribution is from Bair (1992), and the minimum is from Kamboj et al. (1997) for the Hanford site.	Triangular	1.61E-01	1.00E+00	1.62E+00	NR	The average amount of water in the form of rain, snow, hail, or sleet that falls per unit of time at the site.

[a] For truncated lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution, parameter 3 = lower quantile, and parameter 4 = upper quantile; for lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution; for triangular distribution, parameter 1 = minimum, parameter 2 = mode or most likely, and parameter 3 = maximum; for truncated normal distribution, parameter 1 = mean, parameter 2 = standard deviation, parameter 3 = lower quantile, and parameter 4 = upper quantile; for bounded lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution, parameter 3 = minimum value, and parameter 4 = maximum value; for uniform distribution, parameter 1 = minimum, and parameter 2 = maximum; for continuous linear distribution, number of points, value of points, and cdf of points; for continuous logarithmic distribution, number of points, value of points, and cdf of points.

[b] P = physical, B= behavioral, and M = metabolic parameter.

[c] NR = not required.

[d] NA = not applicable.

Note: Density, porosity, and effective porosity are correlated. Correlations are used for uranium isotope Kd values in different zones.

Table B-2 Base Values and Statistical Distributions of Input Parameters Used in the RESRAD-ONSITE Code for the Resident Farmer Scenario Analysis (cont.)

Input Parameter	Units	Type[b]	Base value for deterministic calculation	Source	Probabilistic Analysis[a]					Description
					Distribution	Parameter 1	Parameter 2	Parameter 3	Parameter 4	
Cover and Contaminated Zone Hydrological Data (cont.)										
Irrigation rate	m/yr	B	1.16E-01	The reported value of 1.29 in L/m^2/d (Table 6.87 in NUREG/CR-5512 Volume 3) is converted to give the base value in m/yr, with the assumption that the duration for gardening activities is 90 days/yr.	no	NR	NR	NR	NR	The average volume of water that is added to the soil at the site, per unit of surface area and per unit of time. Irrigation is the practice of supplying water artificially to the soil in order to permit agricultural use of the land in an arid region or to compensate for occasional droughts in semi-dry or semihumid regions. It is the average annual irrigation rate. The code has two irrigation modes: overhead and ditch irrigation.
Irrigation mode	none	B	Overhead		Overhead	NR	NR	NR	NR	Method of irrigation; it could be overhead or ditch.
Runoff coefficient	none	P	3.10E-01	For deterministic calculation, the base value is determined to give an infiltration rate of 0.2526 m/yr (default in DandD code, Table 6.87 in NUREG/CR-5512 Volume 3), when the precipitation rate, evapotranspiration coefficient, and irrigation rate assumed base values. The statistical distribution is from NUREG/CR-6697.	Uniform	1.00E-01	8.00E-01			The fraction of the average annual precipitation that does not infiltrate into the soil and is not transferred back to the atmosphere through evapotranspiration.
Watershed area for nearby stream or pond	m^2	P	1.00E+06	For deterministic calculation, the base value is the default used in RESRAD-ONSITE. A triangular distribution is assumed, with the mode equivalent to the base value, and the minimum set to be 1/100 of the mode.	Triangular	1.00E+04	1.00E+06	1.00E+06	NR	The site-specific area that drains into the nearby pond.
Accuracy for water soil computation	none	NA	1.00E-03		1.00E-03	NR	NR	NR	NR	The fractional accuracy desired (conversion criterion) in the Romberg integration used to obtain water/soil concentration ratios.

[a] For truncated lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution, parameter 3 = lower quantile, and parameter 4 = upper quantile; for lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution; for triangular distribution, parameter 1 = minimum, parameter 2 = mode or most likely, and parameter 3 = maximum; for truncated normal distribution, parameter 1 = mean, parameter 2 = standard deviation, parameter 3 = lower quantile, and parameter 4 = upper quantile; for bounded lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution, parameter 3 = minimum value, and parameter 4 = maximum value; for uniform distribution, parameter 1 = minimum, and parameter 2 = maximum; for continuous linear distribution, number of points, value of points, and cdf of points; for continuous logarithmic distribution, number of points, value of points, and cdf of points.

[b] P = physical, B= behavioral, and M = metabolic parameter.

[c] NR = not required.

[d] NA = not applicable.

Note: Density, porosity, and effective porosity are correlated. Correlations are used for uranium isotope Kd values in different zones.

Table B-2 Base Values and Statistical Distributions of Input Parameters Used in the RESRAD-ONSITE Code for the Resident Farmer Scenario Analysis (cont.)

Input Parameter	Units	Type[b]	Base value for deterministic calculation	Source	Probabilistic Analysis[a]					Description
					Distribution	Parameter 1	Parameter 2	Parameter 3	Parameter 4	
Saturated Zone Hydrological Data										
Density of saturated zone	g/cm^3	P	1.43E+00	The base value is estimated based on the default value used in the DandD code for density (Table 6.87 in NUREG/CR-5512 Volume 3). For probabilistic calculations, the statistical distribution is from NUREG/CR-6697 for generic soil type.	Truncated normal	1.52E+00	2.30E-01	1.00E-03	9.99E-01	See density of contaminated zone (above)
Saturated zone total porosity	none	P	4.60E-01	For deterministic calculation, the base value is the default used in DandD (Table 6.87 in NUREG/CR-5512 Volume 3). For probabilistic calculations, the statistical distribution is from NUREG/CR-6697 for generic soil type.	Truncated normal	4.30E-01	6.99E-02	1.00E-03	9.99E-01	See contaminated zone total porosity (above)
Saturated zone effective porosity	none	P	0.355	For deterministic calculation, the base value is the mean from the statistical distribution. For probabilistic calculations, the statistical distribution is from NUREG/CR-6697 for generic soil type.	Truncated normal	3.42E-01	7.05E-02	1.00E-03	9.99E-01	The effective porosity is the ratio of the pore volume where water can circulate to the total volume. It is used along with other hydrological parameters to calculate the water transport breakthrough times.
Saturated zone field capacity	none	P	2.00E-01	For deterministic calculation, the base value is the default used in RESRAD-ONSITE. For probabilistic calculations, a triangular distribution is used; the mode equivalent to the base value, and the minimum and maximum taken to be 1/2 of and twice, respectively, the base value.	Triangular	1.00E-01	2.00E-01	4.00E-01	NR	See contaminated zone field capacity (above). (The field capacity and b parameter of the saturated zone are used only if the water table drop rate is positive.)

[a] For truncated lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution, parameter 3 = lower quantile, and parameter 4 = upper quantile; for lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution; for triangular distribution, parameter 1 = minimum, parameter 2 = mode or most likely, and parameter 3 = maximum; for truncated normal distribution, parameter 1 = mean, parameter 2 = standard deviation, parameter 3 = lower quantile, and parameter 4 = upper quantile; for bounded lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution, parameter 3 = minimum value, and parameter 4 = maximum value; for uniform distribution, parameter 1 = minimum, and parameter 2 = maximum; for continuous linear distribution, number of points, value of points, and cdf of points; for continuous logarithmic distribution, number of points, value of points, and cdf of points.

[b] P = physical, B= behavioral, and M = metabolic parameter.

[c] NR = not required.

[d] NA = not applicable.

Note: Density, porosity, and effective porosity are correlated. Correlations are used for uranium isotope Kd values in different zones.

Table B-2 Base Values and Statistical Distributions of Input Parameters Used in the RESRAD-ONSITE Code for the Resident Farmer Scenario Analysis (cont.)

Input Parameter	Units	Type[b]	Base value for deterministic calculation	Source	Probabilistic Analysis[a]					Description
					Distribution	Parameter 1	Parameter 2	Parameter 3	Parameter 4	
Saturated Zone Hydrological Data (cont.)										
Saturated zone hydraulic conductivity	m/yr	P	1.00E+01	For deterministic calculation, the base value is the median from the statistical distribution. For probabilistic calculations, the statistical distribution is from NUREG/CR-6697 for generic soil type.	Bounded lognormal-n	2.30E+00	2.11E+00	4.00E-03	9.25E+03	See contaminated zone hydraulic conductivity (above)
Saturated zone hydraulic gradient	none	P	2.00E-02	For deterministic calculation, the base value is the median from the statistical distribution. For probabilistic calculations, the statistical distribution is from NUREG/CR-6697 for generic soil type.	Bounded lognormal-n	-5.11E+00	1.77E+00	7.00E-05	5.00E-01	The change in hydraulic head per unit of distance in the groundwater flow direction. In the unconfined (water table) aquifer, the horizontal hydraulic gradient of groundwater flow is approximately the slope of the water table. In a confined aquifer, it represents the difference in potentiometric surfaces over a unit distance.
Saturated zone b parameter	none	P	3.59E+00	For deterministic calculation, the base value is the mean from the statistical distribution. For probabilistic calculations, the statistical distribution is from NUREG/CR-6697 for generic soil type.	Bounded lognormal-n	1.06E+00	6.60E-01	5.00E-01	3.00E+01	See contaminated zone b parameter (above)
Water table drop rate	m/yr	P	1.00E-03	Base value for deterministic calculation is the RESRAD-ONSITE default value, which is also the mode for the triangular distribution. The minimum and maximum of the triangular distribution are taken to be 1/2 of and twice, respectively, the base value.	Triangular	5.00E-04	1.00E-03	2.00E-03	NR	The rate at which the depth of the water table is lowered. If the water table drop rate is greater than zero, the unsaturated zone thickness will be created or increased. The saturation of newly created unsaturated zone is estimated by the hydrological parameter. The code does not allow negative water table drop rate.
Well pump intake depth (below water table)	m	P	1.00E+01	For deterministic calculation, the base value is the default used in RESRAD-ONSITE. For probabilistic calculations, the distribution is from NUREG/CR-6697.	Triangular	6.00E+00	1.00E+01	3.00E+01		The screened depth of a well within the aquifer (the saturated zone).

[a] For truncated lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution, parameter 3 = lower quantile, and parameter 4 = upper quantile; for lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution; for triangular distribution, parameter 1 = minimum, parameter 2 = mode or most likely, and parameter 3 = maximum; for truncated normal distribution, parameter 1 = mean, parameter 2 = standard deviation, parameter 3 = lower quantile, and parameter 4 = upper quantile; for bounded lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution, parameter 3 = minimum value, and parameter 4 = maximum value; for uniform distribution, parameter 1 = minimum, and parameter 2 = maximum; for continuous linear distribution, number of points, value of points, and cdf of points; for continuous logarithmic distribution, number of points, value of points, and cdf of points.
[b] P = physical, B= behavioral, and M = metabolic parameter.
[c] NR = not required.
[d] NA = not applicable.
Note: Density, porosity, and effective porosity are correlated. Correlations are used for uranium isotope Kd values in different zones.

Table B-2 Base Values and Statistical Distributions of Input Parameters Used in the RESRAD-ONSITE Code for the Resident Farmer Scenario Analysis (cont.)

Input Parameter	Units	Type[b]	Base value for deterministic calculation	Source	Probabilistic Analysis[a]					Description
					Distribution	Parameter 1	Parameter 2	Parameter 3	Parameter 4	
Saturated Zone Hydrological Data (cont.)										
Model: nondispersion (ND) or mass balance (MB)	none	P	ND		No	NR	NR	NR	NR	Two models are used in the code for calculating the water/soil concentration ratio for the groundwater pathway: a mass-balance model (MB) and a nondispersion mode (ND). The MB model assumes that a well is located at the center of the contaminated zone, and the ND model assumes that the well is located at the down gradient edge of the contaminated zone. In the MB model, it is assumed that all of the radionuclides released from the contaminated zone are withdrawn through the well. In the ND model, it is assumed that the saturated zone is a single homogenous stratum.
Well pumping rate	m^3 /yr	B, P	2.50E+02	Base value for deterministic calculation is the RESRAD-ONSITE default value. The minimum value of the uniform distribution is the base value, and the maximum value is based on the water use for 10,000 m^2 land area (NUREG/CR-6697, Table 3.10-1).	Uniform	2.50E+02	1.52E+03			The volume of water removed from the groundwater aquifer annually for all purposes.
Uncontaminated Unsaturated Zone Parameters										
Number of unsaturated zones	none	P	1		No	NR	NR	NR	NR	Number of unsaturated stratum with different soil properties.
Unsaturated zone thickness	m	P	1.23E+00	For deterministic calculation, the base value is the default used in DandD. For probabilistic calculations, the statistical distribution is from NUREG/CR-6697.	Bounded lognormal-n	2.30E+00	1.28E+00	1.80E-01	3.20E+02	The thickness of the uncontaminated unsaturated zone that lies below the bottom of the contaminated zone and above the groundwater table. The code has provisions for up to five different horizontal strata within this zone. Each stratum is characterized by six radionuclide independent parameters: thickness, density, total porosity, effective porosity, b parameter, and hydraulic conductivity.

[a] For truncated lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution, parameter 3 = lower quantile, and parameter 4 = upper quantile; for lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution; for triangular distribution, parameter 1 = minimum, parameter 2 = mode or most likely, and parameter 3 = maximum; for truncated normal distribution, parameter 1 = mean, parameter 2 = standard deviation, parameter 3 = lower quantile, and parameter 4 = upper quantile; for bounded lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution, parameter 3 = minimum value, and parameter 4 = maximum value; for uniform distribution, parameter 1 = minimum, and parameter 2 = maximum; for continuous linear distribution, number of points, value of points, and cdf of points; for continuous logarithmic distribution, number of points, value of points, and cdf of points.

[b] P = physical, B= behavioral, and M = metabolic parameter.

[c] NR = not required.

[d] NA = not applicable.

Note: Density, porosity, and effective porosity are correlated. Correlations are used for uranium isotope Kd values in different zones.

Table B-2 Base Values and Statistical Distributions of Input Parameters Used in the RESRAD-ONSITE Code for the Resident Farmer Scenario Analysis (cont.)

Input Parameter	Units	Type[b]	Base value for deterministic calculation	Source	Probabilistic Analysis[a]					Description
					Distribution	Parameter 1	Parameter 2	Parameter 3	Parameter 4	
Uncontaminated Unsaturated Zone Parameters (cont.)										
Unsaturated zone density	g/cm^3	P	1.43E+00	The base value is estimated based on the default value used in the DandD code for porosity (Table 6.87 in NUREG/CR-5512 Volume 3). For probabilistic calculations, the statistical distribution is from NUREG/CR-6697 for generic soil type.	Truncated normal	1.52E+00	2.30E-01	1.00E-03	9.99E-01	Bulk density of the unsaturated zone soil.
Unsaturated zone total porosity	none	P	4.60E-01	For deterministic calculation, the base value is the default used in DandD (Table 6.87 in NUREG/CR-5512 Volume 3). For probabilistic calculations, the statistical distribution is from NUREG/CR-6697 for generic soil type.	Truncated normal	4.30E-01	6.99E-02	1.00E-03	9.99E-01	See contaminated zone total porosity (above)
Unsaturated zone effective porosity	none	P	3.55E-01	For deterministic calculation, the base value is the median from the statistical distribution. For probabilistic calculations, the statistical distribution is from NUREG/CR-6697 for generic soil type.	Truncated normal	3.42E-01	7.05E-02	1.00E-03	9.99E-01	The effective porosity is the ratio of the pore volume where water can circulate to the total volume.
Unsaturated zone field capacity	none	P	2.00E-01	For deterministic calculation, the base is the default used in RESRAD-ONSITE. For probabilistic calculations, a triangular distribution is used, with the mode equivalent to the base value, and the minimum and maximum taken to be 1/2 of and twice, respectively, the base value.	Triangular	1.00E-01	2.00E-01	4.00E-01	Triangular	See contaminated zone field capacity (above)

[a] For truncated lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution, parameter 3 = lower quantile, and parameter 4 = upper quantile; for lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution; for triangular distribution, parameter 1 = minimum, parameter 2 = mode or most likely, and parameter 3 = maximum; for truncated normal distribution, parameter 1 = mean, parameter 2 = standard deviation, parameter 3 = lower quantile, and parameter 4 = upper quantile; for bounded lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution, parameter 3 = minimum value, and parameter 4 = maximum value; for uniform distribution, parameter 1 = minimum, and parameter 2 = maximum; for continuous linear distribution, number of points, value of points, and cdf of points; for continuous logarithmic distribution, number of points, value of points, and cdf of points.

[b] P = physical, B= behavioral, and M = metabolic parameter.

[c] NR = not required.

[d] NA = not applicable.

Note: Density, porosity, and effective porosity are correlated. Correlations are used for uranium isotope Kd values in different zones.

Table B-2 Base Values and Statistical Distributions of Input Parameters Used in the RESRAD-ONSITE Code for the Resident Farmer Scenario Analysis (cont.)

Input Parameter	Units	Type[b]	Base value for deterministic calculation	Source	Probabilistic Analysis[a]					Description
					Distribution	Parameter 1	Parameter 2	Parameter 3	Parameter 4	
Uncontaminated Unsaturated Zone Parameters (cont.)										
Unsaturated zone hydraulic conductivity	m/yr	P	1.00E+01	For deterministic calculation, the base value is the median from the statistical distribution. For probabilistic calculations, the statistical distribution is from NUREG/CR-6697 for generic soil type.	Bounded lognormal-n	2.30E+00	2.11E+00	4.00E-03	9.25E+03	See contaminated zone hydraulic conductivity (above)
Unsaturated zone b parameter	none	P	3.59E+00	For deterministic calculation, the base value is the median from the statistical distribution. For probabilistic calculations, the statistical distribution is from NUREG/CR-6697 for generic soil type.	Bounded lognormal-n	1.06E+00	6.60E-01	5.00E-01	3.00E+01	See contaminated zone b parameter (above)
Occupancy, Inhalation, and External Gamma Data										
Inhalation rate	m^3 /yr	M, B	8.58E+03	The base value is calculated based on the default inhalation rates (for outdoor, indoor, and gardening activities) and time fractions used in the DandD code.	No	NR	NR	NR	NR	The annual air intake.
Mass loading for inhalation	g/m^3	P, B	3.01E-05	The base value is calculated by using the mass loading values (for outdoor and gardening activities) and time fractions (for outdoor and gardening activities) in the DandD code. For probabilistic calculations, the statistical distribution is from NUREG/CR-6697.	Continuous linear					The air/soil concentration ratio or average mass loading of airborne contaminated soil particles. The code uses this parameter along with area factor for inhalation pathway dose estimation. This average mass loading factor includes short period of high mass loading and sustained periods of normal activity on a typical farm.
Exposure duration	year	B	3.00E+01	The base value is the default used in the RESRAD-ONSITE code.	3.00E+01	NR	NR	NR	NR	The exposure duration is the span of time, in years, during which an individual is expected to spend time on the site. The value is used in calculating lifetime cancer risk from exposure to radionuclide contamination. It is also used to calculate time-integrated dose if exposure duration is less than a year.

[a] For truncated lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution, parameter 3 = lower quantile, and parameter 4 = upper quantile; for lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution; for triangular distribution, parameter 1 = minimum, parameter 2 = mode or most likely, and parameter 3 = maximum; for truncated normal distribution, parameter 1 = mean, parameter 2 = standard deviation, parameter 3 = lower quantile, and parameter 4 = upper quantile; for bounded lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution, parameter 3 = minimum value, and parameter 4 = maximum value; for uniform distribution, parameter 1 = minimum, and parameter 2 = maximum; for continuous linear distribution, number of points, value of points, and cdf of points; for continuous logarithmic distribution, number of points, value of points, and cdf of points.

[b] P = physical, B= behavioral, and M = metabolic parameter.

[c] NR = not required.

[d] NA = not applicable.

Note: Density, porosity, and effective porosity are correlated. Correlations are used for uranium isotope Kd values in different zones.

Table B-2 Base Values and Statistical Distributions of Input Parameters Used in the RESRAD-ONSITE Code for the Resident Farmer Scenario Analysis (cont.)

Input Parameter	Units	Type[b]	Base value for deterministic calculation	Source	Probabilistic Analysis[a]					Description
					Distribution	Parameter 1	Parameter 2	Parameter 3	Parameter 4	
Occupancy, Inhalation, and External Gamma Data (cont.)										
Indoor dust filtration factor	none	P, B	4.49E-01	The base value is the ratio of the dust loading factor indoors to the dust loading factor outdoors used in the DandD code. For probabilistic calculations, the statistical distribution is from NUREG/CR-6697.	Uniform	1.50E-01	9.50E-01			Describes the effect of the building structure on the level of contaminated dust existing indoors. This is the fraction of the outdoor contaminated dust that will be available indoors.
External gamma shielding factor	none	P	5.52E-01	The base value is the default value used in the DandD code for indoor shielding factor (Table 6.87 in NUREG/CR-5512 Volume 3). For probabilistic calculations, the statistical distribution is from NUREG/CR-6697.	Bounded lognormal-n	-1.30E+00	5.90E-01	4.40E-02	1.00E+00	Describes the effect of building structure on the level of gamma radiation existing indoors. It is the fraction of the outdoor gamma radiation that will be available indoors. The shielding factor value is used in calculating the indoor external radiation exposure.
Indoor time fraction	none	B	6.60E-01	The base value is the default value used in the DandD code (ratio of indoor exposure period in days to total time in days as listed in Table 6.87 in NUREG/CR-5512 Volume 3).	NO	NR	NR	NR	NR	The average fraction of time during which an individual stays inside the house.
Outdoor time fraction	none	B	1.20E-01	The base value is the default value used in the DandD code (ratio of outdoor + gardening exposure period in days to total time in days as listed in Table 6.87 in NUREG/CR-5512 Volume 3).	NO	NR	NR	NR	NR	The average fraction of time during which an individual stays outdoors on the site.

[a] For truncated lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution, parameter 3 = lower quantile, and parameter 4 = upper quantile; for lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution; for triangular distribution, parameter 1 = minimum, parameter 2 = mode or most likely, and parameter 3 = maximum; for truncated normal distribution, parameter 1 = mean, parameter 2 = standard deviation, parameter 3 = lower quantile, and parameter 4 = upper quantile; for bounded lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution, parameter 3 = minimum value, and parameter 4 = maximum value; for uniform distribution, parameter 1 = minimum, and parameter 2 = maximum; for continuous linear distribution, number of points, value of points, and cdf of points; for continuous logarithmic distribution, number of points, value of points, and cdf of points.

[b] P = physical, B= behavioral, and M = metabolic parameter.

[c] NR = not required.

[d] NA = not applicable.

Note: Density, porosity, and effective porosity are correlated. Correlations are used for uranium isotope Kd values in different zones.

Table B-2 Base Values and Statistical Distributions of Input Parameters Used in the RESRAD-ONSITE Code for the Resident Farmer Scenario Analysis (cont.)

Input Parameter	Units	Type[b]	Base value for deterministic calculation	Source	Probabilistic Analysis[a]					Description
					Distribution	Parameter 1	Parameter 2	Parameter 3	Parameter 4	
Occupancy, Inhalation, and External Gamma Data (cont.)										
Shape of the contaminated zone (shape factor flag)	none	P	circular		NO	NR	NR	NR	NR	The code has the capability to handle any shape of contaminated zone. If the shape factor flag has been set, the 12 annular area fields comprising shape factor data are input. The shape factor data are calculated by RESRAD-ONSITE by drawing 2 to 12 concentric circles emanating from the receptor location inside (or possibly outside) the contaminated area. The outermost circle circumscribes the entire contaminated zone. For each annular ring, the outer radius and fraction of the ring within the contaminated zone should be entered. For simple shapes (square, rectangle, triangle, doughnut), few circles are sufficient. For complicated shapes, all 12 concentric circles can be used.
Ingestion Pathway, Dietary Data										
Fruit, vegetable and grain consumption	kg/yr	M, B	1.12E+02	The base value is the sum of the defaults used in DandD for fruit, grain, and other vegetable intake (Table 6.87 in NUREG/CR-5512 Volume 3).	NO	NR	NR	NR	NR	3333333333333
I/I/yLeafy vegetable consumption	kg/yr	M, B	2.14E+01	The base value is the default used in DandD for leafy vegetable intake (Table 6.87 in NUREG/CR-5512 Volume 3).	NO	NR	NR	NR	NR	The dietary factor for leafy vegetable consumption by humans. The default is based on national averages.
Milk consumption	L/yr	M, B	2.33E+02	The base value is the default used in DandD for milk intake (Table 6.87 in NUREG/CR-5512 Volume 3).	NO	NR	NR	NR	NR	The dietary factor for milk consumption by humans. The default is based on national averages.
Meat consumption	kg/yr	M, B	6.51E+01	The base value is the sum of the defaults used in DandD for beef and poultry intake (Table 6.87 in NUREG/CR-5512 Volume 3).	NO	NR	NR	NR	NR	The dietary factor for meat consumption by humans. The default is based on national average.

[a] For truncated lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution, parameter 3 = lower quantile, and parameter 4 = upper quantile; for lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution; for triangular distribution, parameter 1 = minimum, parameter 2 = mode or most likely, and parameter 3 = maximum; for truncated normal distribution, parameter 1 = mean, parameter 2 = standard deviation, parameter 3 = lower quantile, and parameter 4 = upper quantile; for bounded lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution, parameter 3 = minimum value, and parameter 4 = maximum value; for uniform distribution, parameter 1 = minimum, and parameter 2 = maximum; for continuous linear distribution, number of points, value of points, and cdf of points; for continuous logarithmic distribution, number of points, value of points, and cdf of points.

[b] P = physical, B= behavioral, and M = metabolic parameter.

[c] NR = not required.

[d] NA = not applicable.

Note: Density, porosity, and effective porosity are correlated. Correlations are used for uranium isotope Kd values in different zones.

Table B-2 Base Values and Statistical Distributions of Input Parameters Used in the RESRAD-ONSITE Code for the Resident Farmer Scenario Analysis (cont.)

Input Parameter	Units	Type[b]	Base value for deterministic calculation	Source	Probabilistic Analysis[a]					Description
					Distribution	Parameter 1	Parameter 2	Parameter 3	Parameter 4	
Ingestion Pathway, Dietary Data (cont.)										
Fish consumption	kg/yr	M, B	2.06E+01	The base value is the default used in DandD for fish intake (Table 6.87 in NUREG/CR-5512 Volume 3).	NO	NR	NR	NR	NR	The dietary factor for fish consumption by humans. The default is based on national averages.
Other seafood consumption	kg/yr	M, B	9.00E-01	The base value is the default used in RESRAD-ONSITE code.	NO	NR	NR	NR	NR	The dietary factor for other seafood consumption by humans. The default is based on national averages.
Soil ingestion rate	g/yr	M, B	1.83E+01	For deterministic calculation, the base value is the default used in DandD (Table 6.87 in NUREG/CR-5512 Volume 3).	NO	NR	NR	NR	NR	The average annual quantity of soil ingested for the soil ingestion pathway.
Drinking water intake	L/yr	M, B	4.60E+02	The base value is the default used in DandD for drinking water (1.31 L/d to 460 L/yr. in RESRAD-Onsite (Table 6.87 in NUREG/CR-5512 Volume 3).	NO	NR	NR	NR	NR	The drinking water ingestion rate.
Drinking water contaminated fraction	none	B, P	1.00E+00	The base value is based on the assumption that all the drinking water is contaminated.	NO	NR	NR	NR	NR	Allows specification of the fraction of contaminated intake for the drinking water pathway. The remaining balance (if value is less than 1) of the drinking water is from off-site sources, which are assumed to be uncontaminated. The default value of 1 indicates that all drinking water is from on-site sources. Setting the value to zero will turn off the drinking water pathway entirely.
Household water contaminated fraction	none	B, P	1.00E+00	The base value is based on the assumption that all the household water is contaminated.	NO	NR	NR	NR	NR	Allows specification of the fraction of contaminated intake of household water for use in calculating radon exposure. The remaining balance (if value is less than 1) of the household water is from off-site sources, which are assumed to be uncontaminated. The default value of 1 indicates that all household water is from on-site sources.

[a] For truncated lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution, parameter 3 = lower quantile, and parameter 4 = upper quantile; for lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution; for triangular distribution, parameter 1 = minimum, parameter 2 = mode or most likely, and parameter 3 = maximum; for truncated normal distribution, parameter 1 = mean, parameter 2 = standard deviation, parameter 3 = lower quantile, and parameter 4 = upper quantile; for bounded lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution, parameter 3 = minimum value, and parameter 4 = maximum value; for uniform distribution, parameter 1 = minimum, and parameter 2 = maximum; for continuous linear distribution, number of points, value of points, and cdf of points; for continuous logarithmic distribution, number of points, value of points, and cdf of points.

[b] P = physical, B= behavioral, and M = metabolic parameter.

[c] NR = not required.

[d] NA = not applicable.

Note: Density, porosity, and effective porosity are correlated. Correlations are used for uranium isotope Kd values in different zones.

Table B-2 Base Values and Statistical Distributions of Input Parameters Used in the RESRAD-ONSITE Code for the Resident Farmer Scenario Analysis (cont.)

Input Parameter	Units	Type[b]	Base value for deterministic calculation	Source	Probabilistic Analysis[a]					Description
					Distribution	Parameter 1	Parameter 2	Parameter 3	Parameter 4	
Ingestion Pathway, Dietary Data (cont.)										
Livestock water contaminated fraction	none	B, P	1.00E+00	The base value is based on the assumption that all the livestock water is contaminated.	NO	NR	NR	NR	NR	Allows specification of the fraction of contaminated intake of livestock water for the meat and milk pathways. The remaining balance (if value is less than 1) of the livestock water is from off-site sources, which are assumed to be uncontaminated. The default value of 1 indicates that all livestock water is from on-site sources.
Irrigation water contaminated fraction	none	B, P	1.00E+00	The base value is based on the assumption that all the irrigation water is contaminated.	NO	NR	NR	NR	NR	Allows specification of the fraction of contaminated intake of irrigation water for the plant, meat and milk pathways. The remaining balance (if value is less than 1) of the irrigation water is from off-site sources, which are assumed to be uncontaminated. The default value of 1 indicates that all irrigation water is from on-site sources.
Aquatic food contaminated fraction	none	B, P	1.00E+00	The base value is based on the assumption that all the ingested aquatic food is contaminated.	NO	NR	NR	NR	NR	Allows specification of the fraction of contaminated intake for the fish pathway. The remaining balance is from off-site sources, which are assumed to be uncontaminated. The default value of 0.5 indicates that 50 percent of the aquatic food is being obtained from on-site sources. Setting the value to 0 will turn off the fish pathway entirely.
Plant food contaminated fraction	none	B, P	1.00E+00	The base value is based on the assumption that all the ingested plant food is contaminated.	NO	NR	NR	NR	NR	Allows specification of the fraction of contaminated intake for the plant pathway. The appropriate values range from 0 to 1, although a negative value can be input. The remaining balance is from off-site sources, which are assumed to be uncontaminated. The default value of -1 specifies that the contaminated fraction of plant food will be calculated from the appropriate area factor in the code. Setting the value to 0 will turn off the plant pathway entirely.

[a] For truncated lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution, parameter 3 = lower quantile, and parameter 4 = upper quantile; for lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution; for triangular distribution, parameter 1 = minimum, parameter 2 = mode or most likely, and parameter 3 = maximum; for truncated normal distribution, parameter 1 = mean, parameter 2 = standard deviation, parameter 3 = lower quantile, and parameter 4 = upper quantile; for bounded lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution, parameter 3 = minimum value, and parameter 4 = maximum value; for uniform distribution, parameter 1 = minimum, and parameter 2 = maximum; for continuous linear distribution, number of points, value of points, and cdf of points; for continuous logarithmic distribution, number of points, value of points, and cdf of points.

[b] P = physical, B= behavioral, and M = metabolic parameter.

[c] NR = not required.

[d] NA = not applicable.

Note: Density, porosity, and effective porosity are correlated. Correlations are used for uranium isotope Kd values in different zones.

Table B-2 Base Values and Statistical Distributions of Input Parameters Used in the RESRAD-ONSITE Code for the Resident Farmer Scenario Analysis (cont.)

Input Parameter	Units	Type[b]	Base value for deterministic calculation	Source	Probabilistic Analysis[a] Distribution	Parameter 1	Parameter 2	Parameter 3	Parameter 4	Description
Ingestion Pathway, Dietary Data (cont.)										
Meat contaminated fraction	none	B, P	1.00E+00	The base value is based on the assumption that all the ingested meat is contaminated.	NO	NR	NR	NR	NR	Allows specification of the fraction of contaminated intake for the meat pathway. The appropriate values range from 0 to 1, although a negative value can be input. The remaining balance is from off-site sources, which are assumed to be uncontaminated. The default value of -1 specifies that the contaminated fraction of meat will be calculated from the appropriate area factor in the code. Setting the value to 0 will turn off the meat pathway entirely.
Milk contaminated fraction	none	B, P	1.00E+00	The base value is based on the assumption that all the ingested milk is contaminated.	NO	NR	NR	NR	NR	Allows specification of the fraction of contaminated intake for the milk pathway. The appropriate values range from 0 to 1, although a negative value can be input. The remaining balance is from off-site sources, which are assumed to be uncontaminated. The default value of -1 specifies that the contaminated fraction of milk will be calculated from the appropriate area factor in the code. Setting the value to 0 will turn off the milk pathway entirely.
Ingestion Pathway, Nondietary Data										
Livestock fodder intake for meat	kg/d	M	2.68E+01	The base value is the default used in DandD for the total intake for beef cattle (Table 6.87 in NUREG/CR-5512 vVolume 3). It is assumed that this parameter has a triangular distribution with the base value as the mode, the minimum being 1/2 of the base value, and the maximum being twice the base value.	Triangular	1.34E+01	2.68E+01	5.36E+01	NR	The daily intake of fodder by livestock kept for meat consumption. The code uses the area factor to calculate the contaminated intake.

[a] For truncated lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution, parameter 3 = lower quantile, and parameter 4 = upper quantile; for lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution; for triangular distribution, parameter 1 = minimum, parameter 2 = mode or most likely, and parameter 3 = maximum; for truncated normal distribution, parameter 1 = mean, parameter 2 = standard deviation, parameter 3 = lower quantile, and parameter 4 = upper quantile; for bounded lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution, parameter 3 = minimum value, and parameter 4 = maximum value; for uniform distribution, parameter 1 = minimum, and parameter 2 = maximum; for continuous linear distribution, number of points, value of points, and cdf of points; for continuous logarithmic distribution, number of points, value of points, and cdf of points.

[b] P = physical, B= behavioral, and M = metabolic parameter.

[c] NR = not required.

[d] NA = not applicable.

Note: Density, porosity, and effective porosity are correlated. Correlations are used for uranium isotope Kd values in different zones.

Table B-2 Base Values and Statistical Distributions of Input Parameters Used in the RESRAD-ONSITE Code for the Resident Farmer Scenario Analysis (cont.)

Input Parameter	Units	Type[b]	Base value for deterministic calculation	Source	Probabilistic Analysis[a]					Description
					Distribution	Parameter 1	Parameter 2	Parameter 3	Parameter 4	
Ingestion Pathway, Nondietary Data (cont.)										
Livestock fodder intake for milk	kg/d	M	6.32E+01	The base value is the default used in DandD for the total intake for milk cow (Table 6.87 in NUREG/CR-5512 Volume 3). It is assumed that this parameter has a triangular distribution with the base value as the mode, the minimum being 1/2 of the base value, and the maximum being twice the base value.	Triangular	3.16E+01	6.32E+01	1.26E+02	NR	The daily intake of fodder by livestock kept for milk consumption. The code uses the area factor to calculate the contaminated intake.
Livestock water intake for meat	L/d	M	5.00E+01	The base value is the default used in DandD for the water intake for beef cattle (Table 6.87 in NUREG/CR-5512 Volume 3). It is assumed that this parameter has a triangular distribution with the base value as the mode, the minimum value being 1/2 of the base value, and the maximum being twice the base value.	Triangular	2.50E+01	5.00E+01	1.00E+02	NR	The daily intake of water by livestock kept for meat consumption. The code uses the area factor to calculate the contaminated intake.
Livestock water intake for milk	L/d	M	6.00E+01	The base value is the default used in DandD for the water intake for milk cow (Table 6.87 in NUREG/CR-5512 Volume 3). It is assumed that this parameter has a triangular distribution with the base value as the mode, the minimum being 1/2 of the base value, and the maximum being twice the base value.	Triangular	3.00E+01	6.00E+01	1.20E+02	NR	The daily intake of water by livestock kept for milk consumption. The code uses the area factor to calculate the contaminated intake.

[a] For truncated lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution, parameter 3 = lower quantile, and parameter 4 = upper quantile; for lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution; for triangular distribution, parameter 1 = minimum, parameter 2 = mode or most likely, and parameter 3 = maximum; for truncated normal distribution, parameter 1 = mean, parameter 2 = standard deviation, parameter 3 = lower quantile, and parameter 4 = upper quantile; for bounded lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution, parameter 3 = minimum value, and parameter 4 = maximum value; for uniform distribution, parameter 1 = minimum, and parameter 2 = maximum; for continuous linear distribution, number of points, value of points, and cdf of points; for continuous logarithmic distribution, number of points, value of points, and cdf of points.

[b] P = physical, B= behavioral, and M = metabolic parameter.

[c] NR = not required.

[d] NA = not applicable.

Note: Density, porosity, and effective porosity are correlated. Correlations are used for uranium isotope Kd values in different zones.

Table B-2 Base Values and Statistical Distributions of Input Parameters Used in the RESRAD-ONSITE Code for the Resident Farmer Scenario Analysis (cont.)

Input Parameter	Units	Type[b]	Base value for deterministic calculation	Source	Probabilistic Analysis[a]					Description
					Distribution	Parameter 1	Parameter 2	Parameter 3	Parameter 4	
Ingestion Pathway, Nondietary Data (cont.)										
Livestock soil intake	kg/d	M	5.00E-01	The base value is the default used in DandD for the soil intake for beef cattle (converted from soil fraction and total food intake in Table 6.87 in NUREG/CR-5512 Volume 3). It is assumed that this parameter has a triangular distribution with the base value as the mode, the minimum being 1/2 of the base value, and the maximum being twice the base value.	Triangular	2.50E-01	5.00E-01	1.00E+00	NR	The daily intake of soil by livestock kept for meat or milk consumption.
Mass loading for foliar deposition	g/m^3	P	3.00E-04	The base value considers the air borne dust level generated by agriculture activities (Section 3.6.2 in Data Collection Handbook). It is assumed that this parameter has a triangular distribution, with the base value as the mode, the minimum being set to the one tenth the base value, and the maximum value being set to 10 times the base value to capture periods of high mass loading during tilling operations.	Triangular	3.00E-05	3.00E-04	3.00E-03	NR	The average mass loading of airborne contaminated soil particles in a garden during the growing season.
Depth of soil mixing layer	m	P	1.50E-01	For deterministic calculation, the base value is the default used in RESRAD-ONSITE. For probabilistic calculations, the statistical distribution from NUREG/CR-6697 is used.	Triangular	0.00E+00	1.50E-01	6.00E-01		Used in calculating the depth factor for dust inhalation and soil ingestion pathways and for foliar deposition for the plant, meat, milk ingestion pathways. The depth factor is the fraction of the resuspended soil particles at the ground surface that are contaminated. It is calculated by assuming that mixing of soil will occur in the soil mixing layer.

[a] For truncated lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution, parameter 3 = lower quantile, and parameter 4 = upper quantile; for lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution; for triangular distribution, parameter 1 = minimum, parameter 2 = mode or most likely, and parameter 3 = maximum; for truncated normal distribution, parameter 1 = mean, parameter 2 = standard deviation, parameter 3 = lower quantile, and parameter 4 = upper quantile; for bounded lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution, parameter 3 = minimum value, and parameter 4 = maximum value; for uniform distribution, parameter 1 = minimum, and parameter 2 = maximum; for continuous linear distribution, number of points, value of points, and cdf of points; for continuous logarithmic distribution, number of points, value of points, and cdf of points.

[b] P = physical, B= behavioral, and M = metabolic parameter.

[c] NR = not required.

[d] NA = not applicable.

Note: Density, porosity, and effective porosity are correlated. Correlations are used for uranium isotope Kd values in different zones.

Table B-2 Base Values and Statistical Distributions of Input Parameters Used in the RESRAD-ONSITE Code for the Resident Farmer Scenario Analysis (cont.)

Input Parameter	Units	Type[b]	Base value for deterministic calculation	Source	Probabilistic Analysis[a]					Description
					Distribution	Parameter 1	Parameter 2	Parameter 3	Parameter 4	
Ingestion Pathway, Nondietary Data (cont.)										
Depth of roots	m	P	2.15E+00	For deterministic calculation, the base value is the mean from the statistical distribution. For probabilistic calculations, the statistical distribution from NUREG/CR-6697 is used.	Uniform	3.00E-01	4.00E+00			The maximum root depth below the ground surface.
Groundwater fractional usage for drinking water	none	B, P	1.00E+00	The base value is based on the assumption that all the water used for drinking is groundwater.	NO	NR	NR	NR	NR	The four groundwater fractional usage parameters (drinking water, household water, livestock water, and irrigation water) are included primarily for all groundwater (well or spring) and surface water (pond or river) scenarios. Hence the fractions will usually be set at 1 or 0. A value of 1 specifies 100 percent groundwater usage and 0 selects 100 percent surface water usage.
Groundwater fractional usage for household water	none	B, P	1.00E+00	The base value is based on the assumption that all the water used for household is groundwater.	NO	NR	NR	NR	NR	See groundwater fractional usage for drinking water (above).
Groundwater fractional usage for livestock water	none	B, P	1.00E+00	The base value is based on the assumption that all the water used for livestock is groundwater.	NO	NR	NR	NR	NR	See groundwater fractional usage for drinking water (above).
Groundwater fractional usage for irrigation water	none	B, P	1.00E+00	The base value is based on the assumption that all the water used for irrigation is groundwater.	NO	NR	NR	NR	NR	See groundwater fractional usage for drinking water (above).

[a] For truncated lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution, parameter 3 = lower quantile, and parameter 4 = upper quantile; for lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution; for triangular distribution, parameter 1 = minimum, parameter 2 = mode or most likely, and parameter 3 = maximum; for truncated normal distribution, parameter 1 = mean, parameter 2 = standard deviation, parameter 3 = lower quantile, and parameter 4 = upper quantile; for bounded lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution, parameter 3 = minimum value, and parameter 4 = maximum value; for uniform distribution, parameter 1 = minimum, and parameter 2 = maximum; for continuous linear distribution, number of points, value of points, and cdf of points; for continuous logarithmic distribution, number of points, value of points, and cdf of points.

[b] P = physical, B= behavioral, and M = metabolic parameter.

[c] NR = not required.

[d] NA = not applicable.

Note: Density, porosity, and effective porosity are correlated. Correlations are used for uranium isotope Kd values in different zones.

Table B-2 Base Values and Statistical Distributions of Input Parameters Used in the RESRAD-ONSITE Code for the Resident Farmer Scenario Analysis (cont.)

Input Parameter	Units	Type[b]	Base value for deterministic calculation	Source	Probabilistic Analysis[a]					Description
					Distribution	Parameter 1	Parameter 2	Parameter 3	Parameter 4	
Plant Factors										
Wet weight crop yield for non-leafy vegetables	kg/m^2	P	2.40E+00	The base value used in the deterministic calculation is the default used in DandD code for crop yield for grain, fruit, and other vegetables (Table 6.87 in NUREG/CR-5512, Volume 3). For the probabilistic calculations, a truncated lognormal-n distribution from NUREG/CR-6697 is used.	Truncated lognormal-n	5.60E-01	4.80E-01	1.00E-03	9.99E-01	The weight of the edible portion of plant food produced per unit land area for different food classes. The code has wet weight crop yield for non-leafy, leafy, and fodder. The non-leafy (includes non-leafy vegetables, fruit, and grain) and leafy vegetables for human and fodder for animal consumption.
Wet weight crop yield for leafy vegetables	kg/m^2	P	2.90E+00	The base value used in the deterministic calculation is the default used in DandD code for crop yield for leafy vegetables (Table 6.87 in NUREG/CR-5512, Volume 3). For the probabilistic calculations, a triangular distribution is used, with the mode at the base value, and the minimum and maximum from Table 6.87 in NUREG/CR-5512, Volume 3.	Triangular	2.70E+00	2.90E+00	3.10E+00	NR	See wet weight crop yield for non-leafy (above).
Wet weight crop yield for fodder	kg/m^2	P	1.89E+00	The base value used in the deterministic calculation is the default used in DandD code for crop yield for forage (Table 6.87 in NUREG/CR-5512 Volume 3). For the probabilistic calculations, a triangular distribution is used, with the mode at the base value and the minimum and maximum from Table 6.87 in NUREG/CR-5512.	Triangular	1.19E+00	1.89E+00	2.77E+00	NR	See wet weight crop yield for non-leafy (above).

[a] For truncated lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution, parameter 3 = lower quantile, and parameter 4 = upper quantile; for lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution; for triangular distribution, parameter 1 = minimum, parameter 2 = mode or most likely, and parameter 3 = maximum; for truncated normal distribution, parameter 1 = mean, parameter 2 = standard deviation, parameter 3 = lower quantile, and parameter 4 = upper quantile; for bounded lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution, parameter 3 = minimum value, and parameter 4 = maximum value; for uniform distribution, parameter 1 = minimum, and parameter 2 = maximum; for continuous linear distribution, number of points, value of points, and cdf of points; for continuous logarithmic distribution, number of points, value of points, and cdf of points.

[b] P = physical, B= behavioral, and M = metabolic parameter.

[c] NR = not required.

[d] NA = not applicable.

Note: Density, porosity, and effective porosity are correlated. Correlations are used for uranium isotope Kd values in different zones.

Table B-2 Base Values and Statistical Distributions of Input Parameters Used in the RESRAD-ONSITE Code for the Resident Farmer Scenario Analysis (cont.)

Input Parameter	Units	Type[b]	Base value for deterministic calculation	Source	Probabilistic Analysis[a]					Description
					Distribution	Parameter 1	Parameter 2	Parameter 3	Parameter 4	
Plant Factors (cont.)										
Length of growing season for non-leafy vegetables	year	P	2.47E-01	The value used in the deterministic run is from the default used in DandD code for length of growing period (converted from 90 days to 0.247 yr in RESRAD) for other vegetables (Table 6.87 in NUREG/CR-5512, Volume 3).	NO	NR	NR	NR	NR	The exposure time to contamination for the plant food during the growing season. The contamination can reach the edible portion of the plant food through foliar deposition, root uptake, and water irrigation. The code has length of growing season for non-leafy vegetables, leafy vegetables, and fodder.
Length of growing season for leafy vegetables	year	P	1.23E-01	The value used in the deterministic run is from the default used in DandD code for length of growing period (converted from 45 days to 0.123 yr in RESRAD) for leafy vegetables (Table 6.87 in NUREG/CR-5512, Volume 3).	NO	NR	NR	NR	NR	See length of growing season for non-leafy vegetables (above).
Length of growing season for fodder	year	P	8.20E-02	The value used in the deterministic run is from the default used in DandD code for length of growing period (converted from 30 days to 0.082 yr in RESRAD) for forage (Table 6.87 in NUREG/CR-5512, Volume 3).	NO	NR	NR	NR	NR	See length of growing season for non-leafy vegetables (above).
Translocation factor for non-leafy vegetables	none	P	1.00E-01	The value used in the deterministic run is from the default used in DandD code for translocation factor for grain, fruit, and other vegetables (Table 6.87 in NUREG/CR-5512, Volume 3).	NO	NR	NR	NR	NR	The fraction of contamination that is retained on the foliage that is transferred to the edible portion of the plant. The code has three food categories, non-leafy (includes non-leafy vegetables, fruit, and grain) and leafy vegetables for human and fodder for animal consumption.
Translocation factor for leafy vegetables	none	P	1.00E+00	The value used in the deterministic run is from the default used in DandD code for translocation factor for leafy vegetables (Table 6.87 in NUREG/CR-5512, Volume 3).	NO	NR	NR	NR	NR	See translocation factor for non-leafy vegetables (above).

[a] For truncated lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution, parameter 3 = lower quantile, and parameter 4 = upper quantile; for lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution; for triangular distribution, parameter 1 = minimum, parameter 2 = mode or most likely, and parameter 3 = maximum; for truncated normal distribution, parameter 1 = mean, parameter 2 = standard deviation, parameter 3 = lower quantile, and parameter 4 = upper quantile; for bounded lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution, parameter 3 = minimum value, and parameter 4 = maximum value; for uniform distribution, parameter 1 = minimum, and parameter 2 = maximum; for continuous linear distribution, number of points, value of points, and cdf of points; for continuous logarithmic distribution, number of points, value of points, and cdf of points.

[b] P = physical, B= behavioral, and M = metabolic parameter.

[c] NR = not required.

[d] NA = not applicable.

Note: Density, porosity, and effective porosity are correlated. Correlations are used for uranium isotope Kd values in different zones.

Table B-2 Base Values and Statistical Distributions of Input Parameters Used in the RESRAD-ONSITE Code for the Resident Farmer Scenario Analysis (cont.)

Input Parameter	Units	Type[b]	Base value for deterministic calculation	Source	Probabilistic Analysis[a]					Description
					Distribution	Parameter 1	Parameter 2	Parameter 3	Parameter 4	
Plant Factors (cont.)										
Translocation factor for fodder	none	P	1.00E+00	The value used in the deterministic run is from the default used in DandD code for translocation factor for forage (Table 6.87 in NUREG/CR-5512, Volume 3).	NO	NR	NR	NR	NR	See translocation factor for non-leafy vegetables (above).
Weathering removal constant	1/yr	P	1.80E+01	For deterministic run the value selected is the median from the distribution. For probabilistic analysis triangular distribution from NUREG/CR-6697 is used.	Triangular	5.10E+00	1.80E+01	8.40E+01		The weathering process would remove contaminants from foliage of the plant food. The process is characterized by a removal constant and reduces the amount of contaminants on foliage exponentially during the exposure period.
Wet foliar interception fraction for non-leafy vegetables	none	P	3.50E-01	The value used in the deterministic run is from the default used in DandD code for interception fraction for grain, fruit, and other vegetables (Table 6.87 in NUREG/CR-5512, Volume 3). For the probabilistic run, triangular distribution with mode at default value and min and max from Table 6.87 are used.	Triangular	1.00E-01	3.50E-01	6.00E-01	NR	The fraction of deposited radionuclides that is retained on the foliage of the plant food. Both dry deposition (from airborne particulates) and the wet deposition processes (from irrigation) are considered. The code has wet as well as dry foliar interception fraction for non-leafy vegetables, leafy vegetables (for human consumption), and fodder (for animal consumption).
Wet foliar interception fraction for leafy vegetables	none	P	3.50E-01	The value used in the deterministic run is from the default used in DandD code for interception fraction for leafy vegetables (Table 6.87 in NUREG/CR-5512, Volume 3) and for the probabilistic run, distribution from NUREG/CR-6697 is used.	Triangular	6.00E-02	6.70E-01	9.50E-01		See wet foliar interception fraction (above).
Wet foliar interception fraction for fodder	none	P	3.50E-01	The value used in the deterministic run is from the default used in DandD code for interception fraction for forage (Table 6.87 in NUREG/CR-5512, Volume 3). For the probabilistic run, triangular distribution with mode at default value and min and max from Table 6.87 are used.	Triangular	1.00E-01	3.50E-01	6.00E-01	NR	See wet foliar interception fraction (above).

[a] For truncated lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution, parameter 3 = lower quantile, and parameter 4 = upper quantile; for lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution; for triangular distribution, parameter 1 = minimum, parameter 2 = mode or most likely, and parameter 3 = maximum; for truncated normal distribution, parameter 1 = mean, parameter 2 = standard deviation, parameter 3 = lower quantile, and parameter 4 = upper quantile; for bounded lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution, parameter 3 = minimum value, and parameter 4 = maximum value; for uniform distribution, parameter 1 = minimum, and parameter 2 = maximum; for continuous linear distribution, number of points, value of points, and cdf of points; for continuous logarithmic distribution, number of points, value of points, and cdf of points.

[b] P = physical, B= behavioral, and M = metabolic parameter.

[c] NR = not required.

[d] NA = not applicable.

Note: Density, porosity, and effective porosity are correlated. Correlations are used for uranium isotope Kd values in different zones.

Table B-2 Base Values and Statistical Distributions of Input Parameters Used in the RESRAD-ONSITE Code for the Resident Farmer Scenario Analysis (cont.)

Input Parameter	Units	Type[b]	Base value for deterministic calculation	Source	Probabilistic Analysis[a]					Description
					Distribution	Parameter 1	Parameter 2	Parameter 3	Parameter 4	
Plant Factors (cont.)										
Dry-foliar interception fraction for non-leafy vegetables	none	P	3.50E-01	The value used in the deterministic run is from the default used in DandD code for interception fraction for grain, fruit, and other vegetables (Table 6.87 in NUREG/CR-5512, Volume 3). For the probabilistic run, triangular distribution with mode at default value and min and max from Table 6.87 are used.	Triangular	1.00E-01	3.50E-01	6.00E-01	NR	See wet foliar interception fraction (above).
Dry-foliar interception fraction for leafy vegetables	none	P	3.50E-01	The value used in the deterministic run is from the default used in DandD code for interception fraction for leafy vegetables (Table 6.87 in NUREG/CR-5512, Volume 3). For the probabilistic run, triangular distribution with mode at default value and min and max from Table 6.87 are used.	Triangular	1.00E-01	3.50E-01	6.00E-01	NR	See wet foliar interception fraction (above).
Dry-foliar interception fraction for fodder	none	P	3.50E-01	The base value used in the deterministic calculation is the default used in DandD code for interception fraction for forage (Table 6.87 in NUREG/CR-5512, Volume 3). For the probabilistic calculations, a triangular distribution is used, with the mode at the base value, and the minimum and maximum from Table 6.87 of NUREG/CR-5512.	Triangular	1.00E-01	3.50E-01	6.00E-01	NR	See wet foliar interception fraction (above).

[a] For truncated lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution, parameter 3 = lower quantile, and parameter 4 = upper quantile; for lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution; for triangular distribution, parameter 1 = minimum, parameter 2 = mode or most likely, and parameter 3 = maximum; for truncated normal distribution, parameter 1 = mean, parameter 2 = standard deviation, parameter 3 = lower quantile, and parameter 4 = upper quantile; for bounded lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution, parameter 3 = minimum value, and parameter 4 = maximum value; for uniform distribution, parameter 1 = minimum, and parameter 2 = maximum; for continuous linear distribution, number of points, value of points, and cdf of points; for continuous logarithmic distribution, number of points, value of points, and cdf of points.

[b] P = physical, B= behavioral, and M = metabolic parameter.

[c] NR = not required.

[d] NA = not applicable.

Note: Density, porosity, and effective porosity are correlated. Correlations are used for uranium isotope Kd values in different zones.

Table B-2 Base Values and Statistical Distributions of Input Parameters Used in the RESRAD-ONSITE Code for the Resident Farmer Scenario Analysis (cont.)

Input Parameter	Units	Type[b]	Base value for deterministic calculation	Source	Probabilistic Analysis[a]					Description
					Distribution	Parameter 1	Parameter 2	Parameter 3	Parameter 4	
Radon Data										
Cover total porosity	none	P	4.00E-01	The base value used in the deterministic calculation is the default used in RESRAD-ONSITE code. It is assumed that this parameter has a triangular distribution, with the base value as the mode, the minimum being the lower limit and the maximum being the upper limit for total porosity for different soil types (Table 3.2-1 in NUREG/CR-6697).	Triangular	1.02E-01	4.00E-01	7.96E-01	NR	The ratio of the void space volume to the total volume of the porous medium.
Cover volumetric water content	none	P	5.00E-02	The base value used in the deterministic calculation is the default used in RESRAD-ONSITE code. It is assumed that this parameter has a triangular distribution, with the base value as the mode, the minimum value being 1/2 of the base value, and the maximum being twice the base value.	Triangular	2.50E-02	5.00E-02	1.00E-01	NR	The fraction of the total volume of the porous medium that is occupied by water.
Cover radon diffusion coefficient	m^2 /s	P	2.00E-06	The base value used in the deterministic calculation is the default used in RESRAD-ONSITE code. It is assumed that this parameter has a triangular distribution, with the base value as the mode, the minimum being 1/10 of the base value, and the maximum being the maximum for uranium mill tailings as obtained from Table 4.1.1 in the updated data collection handbook (Yu et al., 2015).	Triangular	2.00E-07	2.00E-06	7.00E-06	NR	The effective (or interstitial) radon diffusion coefficient is the ratio of the diffusive flux density of radon activity across the pore area to the gradient of the radon activity concentration in the pore space. Entering -1 for any diffusion coefficient will cause the code to calculate its value based on the porosity and water content of the medium.

[a] For truncated lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution, parameter 3 = lower quantile, and parameter 4 = upper quantile; for lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution; for triangular distribution, parameter 1 = minimum, parameter 2 = mode or most likely, and parameter 3 = maximum; for truncated normal distribution, parameter 1 = mean, parameter 2 = standard deviation, parameter 3 = lower quantile, and parameter 4 = upper quantile; for bounded lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution, parameter 3 = minimum value, and parameter 4 = maximum value; for uniform distribution, parameter 1 = minimum, and parameter 2 = maximum; for continuous linear distribution, number of points, value of points, and cdf of points; for continuous logarithmic distribution, number of points, value of points, and cdf of points.

[b] P = physical, B= behavioral, and M = metabolic parameter.

[c] NR = not required.

[d] NA = not applicable.

Note: Density, porosity, and effective porosity are correlated. Correlations are used for uranium isotope Kd values in different zones.

Table B-2 Base Values and Statistical Distributions of Input Parameters Used in the RESRAD-ONSITE Code for the Resident Farmer Scenario Analysis (cont.)

Input Parameter	Units	Type[b]	Base value for deterministic calculation	Source	Probabilistic Analysis[a]					Description
					Distribution	Parameter 1	Parameter 2	Parameter 3	Parameter 4	
Radon Data (cont.)										
Building foundation thickness	m	P	1.50E-01	The base value used in the deterministic calculation is the default used in RESRAD-ONSITE code. It is assumed that this parameter has a triangular distribution, with the base value as the mode, the minimum being 1/2 of the base value, and the maximum being twice the base value.	Triangular	7.50E-02	1.50E-01	3.00E-01	NR	Average thickness of the building shell structure in the subsurface of the soil.
Building foundation density	g/cm^3	P	2.40E+00	The base value used in the deterministic calculation is the default used in RESRAD-ONSITE code. For probabilistic calculations, the statistical distribution from NUREG/CR-6755 is used.	Triangular	2.20E+00	2.40E+00	2.60E+00	NR	The solid phase of mass to the total volume.
Building foundation total porosity	none	P	1.00E-01	The base value used in the deterministic calculation is the default used in RESRAD-ONSITE code. It is assumed that this parameter has a triangular distribution, with the base value as the mode, the minimum and the maximum being those for concrete (NUREG/CR-6755).	Triangular	4.00E-02	1.00E-01	2.50E-01	NR	See cover total porosity (above).
Building foundation volumetric water content	none	P	3.00E-02	The base value used in the deterministic calculation is the default used in RESRAD-ONSITE code. It is assumed that this parameter has a triangular distribution, with the base value as the mode, the minimum being 1/2 of the base value, and the maximum being twice the base value.	Triangular	1.50E-02	3.00E-02	6.00E-02	NR	See cover volumetric water content (above).

[a] For truncated lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution, parameter 3 = lower quantile, and parameter 4 = upper quantile; for lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution; for triangular distribution, parameter 1 = minimum, parameter 2 = mode or most likely, and parameter 3 = maximum; for truncated normal distribution, parameter 1 = mean, parameter 2 = standard deviation, parameter 3 = lower quantile, and parameter 4 = upper quantile; for bounded lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution, parameter 3 = minimum value, and parameter 4 = maximum value; for uniform distribution, parameter 1 = minimum, and parameter 2 = maximum; for continuous linear distribution, number of points, value of points, and cdf of points; for continuous logarithmic distribution, number of points, value of points, and cdf of points.

[b] P = physical, B= behavioral, and M = metabolic parameter.

[c] NR = not required.

[d] NA = not applicable.

Note: Density, porosity, and effective porosity are correlated. Correlations are used for uranium isotope Kd values in different zones.

Table B-2 Base Values and Statistical Distributions of Input Parameters Used in the RESRAD-ONSITE Code for the Resident Farmer Scenario Analysis (cont.)

Input Parameter	Units	Type[b]	Base value for deterministic calculation	Source	Probabilistic Analysis[a]					Description
					Distribution	Parameter 1	Parameter 2	Parameter 3	Parameter 4	
Radon Data (cont.)										
Building foundation radon diffusion coefficient	m^2 /s	P	3.00E-07	The base value used in the deterministic calculation is the default used in RESRAD-ONSITE code. It is assumed that this parameter has a triangular distribution, with the base value as the mode, the minimum being 1/10 of the base value, and the maximum being that for concrete as in the updated data collection handbook Table 4.1.1 (Yu et al., 2015).	Triangular	3.00E-08	3.00E-07	5.00E-07	NR	See cover radon diffusion coefficient (above).
Contaminated zone radon diffusion coefficient	m^2 /s	P	2.00E-06	The base value used in the deterministic calculation is the default used in RESRAD-ONSITE code. It is assumed that this parameter has a triangular distribution, with the base value as the mode, the minimum being 1/10 of the base value, and the maximum being that for uranium mill tailings as in the updated data collection handbook Table 4.1.1 (Yu et al., 2015).	Triangular	2.00E-07	2.00E-06	7.00E-06	NR	See cover radon diffusion coefficient (above).
Radon vertical dimension of mixing	m	P	2.00E+00	The base value used in the deterministic calculation is the default used in RESRAD-ONSITE code. It is assumed that this parameter has a triangular distribution, with the base value as the mode, the minimum being 1/2 of the base value, and the maximum being twice the base value.	triangular	1.00E+00	2.00E+00	4.00E+00	NR	The height into which the plume of radon is uniformly mixed in the outdoor air (above).

[a] For truncated lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution, parameter 3 = lower quantile, and parameter 4 = upper quantile; for lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution; for triangular distribution, parameter 1 = minimum, parameter 2 = mode or most likely, and parameter 3 = maximum; for truncated normal distribution, parameter 1 = mean, parameter 2 = standard deviation, parameter 3 = lower quantile, and parameter 4 = upper quantile; for bounded lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution, parameter 3 = minimum value, and parameter 4 = maximum value; for uniform distribution, parameter 1 = minimum, and parameter 2 = maximum; for continuous linear distribution, number of points, value of points, and cdf of points; for continuous logarithmic distribution, number of points, value of points, and cdf of points.

[b] P = physical, B= behavioral, and M = metabolic parameter.

[c] NR = not required.

[d] NA = not applicable.

Note: Density, porosity, and effective porosity are correlated. Correlations are used for uranium isotope Kd values in different zones.

Table B-2 Base Values and Statistical Distributions of Input Parameters Used in the RESRAD-ONSITE Code for the Resident Farmer Scenario Analysis (cont.)

Input Parameter	Units	Type[b]	Base value for deterministic calculation	Source	Probabilistic Analysis[a]					Description
					Distribution	Parameter 1	Parameter 2	Parameter 3	Parameter 4	
Radon Data (cont.)										
Building air exchange rate	/hour	P, B	1.52E+00	For deterministic calculation, the base value is the median from the statistical distribution. For probabilistic calculations, the statistical distribution from NUREG/CR-6755 is used.	Lognormal-n	4.19E-01	8.80E-01	1.00E-03	9.99E-01	The building exchange rate (or ventilation) is defined as the number of the total volumes of air contained in the building being exchanged with outside air per unit of time.
Building room height	m	P	3.70E+00	For deterministic calculation, the base value is the median from the statistical distribution. For probabilistic calculations, the statistical distribution from NUREG/CR-6755 is used.	Triangular	2.40E+00	3.70E+00	9.10E+00	NR	The average height of rooms in the building.
Building indoor area factor	none	P	0.00E+00	The base value used in the deterministic calculation is the default used in RESRAD-ONSITE code.	NO	NR	NR	NR	NR	The fraction of the area for radon to diffuse into indoor air vs. the floor area of the building built on the contaminated soil. Values greater than 1 indicate radon could diffuse from adjacent walls. A default value of zero would prompt the RESRAD-ONSITE code to calculate this time dependent area factor by assuming the floor area is 100 m^2 and considering the extent the adjacent walls extending into the contaminated zone. This factor could be time dependent because of erosion of contaminated soil.
Foundation depth below ground surface	m	P	-1.00E+00	The base value used in the deterministic calculation is the default used in RESRAD-ONSITE code.	NO	NR	NR	NR	NR	The vertical distance in soil, immediately from the bottom of the basement floor slab to the ground surface. The default value is -1; which instructs the RESRAD-ONSITE code to consider that the bottom of the basement floor slab will not extend into the contaminated zone at any time at which dose is calculated.

[a] For truncated lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution, parameter 3 = lower quantile, and parameter 4 = upper quantile; for lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution; for triangular distribution, parameter 1 = minimum, parameter 2 = mode or most likely, and parameter 3 = maximum; for truncated normal distribution, parameter 1 = mean, parameter 2 = standard deviation, parameter 3 = lower quantile, and parameter 4 = upper quantile; for bounded lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution, parameter 3 = minimum value, and parameter 4 = maximum value; for uniform distribution, parameter 1 = minimum, and parameter 2 = maximum; for continuous linear distribution, number of points, value of points, and cdf of points; for continuous logarithmic distribution, number of points, value of points, and cdf of points.

[b] P = physical, B= behavioral, and M = metabolic parameter.

[c] NR = not required.

[d] NA = not applicable.

Note: Density, porosity, and effective porosity are correlated. Correlations are used for uranium isotope Kd values in different zones.

Table B-2 Base Values and Statistical Distributions of Input Parameters Used in the RESRAD-ONSITE Code for the Resident Farmer Scenario Analysis (cont.)

Input Parameter	Units	Type[b]	Base value for deterministic calculation	Source	Probabilistic Analysis[a]					Description
					Distribution	Parameter 1	Parameter 2	Parameter 3	Parameter 4	
Radon Data (cont.)										
Radon 222 emanation coefficient	none	P	2.50E-01	The base value used in the deterministic calculation is the default used in RESRAD-ONSITE code. It is assumed that this parameter has a triangular distribution, with the base value as the mode, and the minimum and the maximum being those for all different types of soil in the U.S. Table 4.2.5 of the updated data collection handbook (Yu et al., 2015) lists the parameter value for different types of soil in the United States.	Triangular	2.00E-02	2.50E-01	7.00E-01	NR	The fraction of the total radon generated by the decay of radium that escapes the solid phase to the pore space. (Depends on such parameters as porosity, particle size distribution, mineralogy, and moisture content.)
Radon 220 emanation coefficient	none	P	1.50E-01	The base value used in the deterministic calculation is the default used in RESRAD-ONSITE code. It is assumed that this parameter has a triangular distribution, with the base value as the mode, and the minimum and maximum being (mean -1 SD) and (mean +1 SD), respectively, of the parameter values listed in Table 4.2.1 of the updated data collection handbook (Yu et al., 2015).	Triangular	9.00E-02	1.50E-01	2.20E-01	NR	See radon 222 emanation coefficient (above).
Storage times before use data										
Non-leafy vegetables, fruits, and grain	days	B	1.40E+01	The base value is the default in DandD code for holdup period for grain, fruit, and other vegetables (Table 6.87 in NUREG/CR-5512, Volume 3).	1.40E+01	NR	NR	NR	NR	The storage times are used to calculate radioactive ingrowth and decay adjustment factors for food and feed due to storage. The code has values for fruits, non-leafy vegetables, and grain; leafy vegetables; milk; well water; surface water; livestock fodder; meat; fish; and Crustacea, and mollusks.

[a] For truncated lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution, parameter 3 = lower quantile, and parameter 4 = upper quantile; for lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution; for triangular distribution, parameter 1 = minimum, parameter 2 = mode or most likely, and parameter 3 = maximum; for truncated normal distribution, parameter 1 = mean, parameter 2 = standard deviation, parameter 3 = lower quantile, and parameter 4 = upper quantile; for bounded lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution, parameter 3 = minimum value, and parameter 4 = maximum value; for uniform distribution, parameter 1 = minimum, and parameter 2 = maximum; for continuous linear distribution, number of points, value of points, and cdf of points; for continuous logarithmic distribution, number of points, value of points, and cdf of points.

[b] P = physical, B= behavioral, and M = metabolic parameter.

[c] NR = not required.

[d] NA = not applicable.

Note: Density, porosity, and effective porosity are correlated. Correlations are used for uranium isotope Kd values in different zones.

Table B-2 Base Values and Statistical Distributions of Input Parameters Used in the RESRAD-ONSITE Code for the Resident Farmer Scenario Analysis (cont.)

Input Parameter	Units	Type[b]	Base value for deterministic calculation	Source	Probabilistic Analysis[a]					Description
					Distribution	Parameter 1	Parameter 2	Parameter 3	Parameter 4	
Storage times before use data (cont.)										
Leafy vegetables	days	B	1.00E+00	The base value is the default in DandD code for holdup period for leafy vegetables (Table 6.87 in NUREG/CR-5512, Volume 3).	1.00E+00	NR	NR	NR	NR	See above.
Milk	days	B	1.00E+00	The base value is the default in DandD code for holdup period for milk (Table 6.87 in NUREG/CR-5512, Volume 3).	1.00E+00	NR	NR	NR	NR	See above.
Meat	days	B	2.00E+01	The base value is the default in DandD code for holdup period for milk (Table 6.87 in NUREG/CR-5512, Volume 3).	2.00E+01	NR	NR	NR	NR	See above.
Fish	days	B	7.00E+00	The base value is RESRAD-ONSITE default.	7.00E+00	NR	NR	NR	NR	See above.
Crustacea and mollusk	days	B	7.00E+00	The base value is RESRAD-ONSITE default.	7.00E+00	NR	NR	NR	NR	See above.
Well water	days	B	1.00E+00	The base value is the default used in DandD code for holdup period for water (Table 6.87 in NUREG/CR-5512, Volume 3).	1.00E+00	NR	NR	NR	NR	See above.
Surface water	days	B	1.00E+00	The base value is the default in DandD code for holdup period for water (Table 6.87 in NUREG/CR-5512, Volume 3).	1.00E+00	NR	NR	NR	NR	See above.
Livestock fodder	days	B	4.50E+01	The base value is RESRAD-ONSITE default.	4.50E+01	NR	NR	NR	NR	For livestock fodder the storage time is an annual average. The default value is obtained by assuming 6 months of outside grazing and 6 months of silage fodder with an average silo time of 3 months.

[a] For truncated lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution, parameter 3 = lower quantile, and parameter 4 = upper quantile; for lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution; for triangular distribution, parameter 1 = minimum, parameter 2 = mode or most likely, and parameter 3 = maximum; for truncated normal distribution, parameter 1 = mean, parameter 2 = standard deviation, parameter 3 = lower quantile, and parameter 4 = upper quantile; for bounded lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution, parameter 3 = minimum value, and parameter 4 = maximum value; for uniform distribution, parameter 1 = minimum, and parameter 2 = maximum; for continuous linear distribution, number of points, value of points, and cdf of points; for continuous logarithmic distribution, number of points, value of points, and cdf of points.

[b] P = physical, B= behavioral, and M = metabolic parameter.

[c] NR = not required.

[d] NA = not applicable.

Note: Density, porosity, and effective porosity are correlated. Correlations are used for uranium isotope Kd values in different zones.

Table B-2 Base Values and Statistical Distributions of Input Parameters Used in the RESRAD-ONSITE Code for the Resident Farmer Scenario Analysis (cont.)

Input Parameter	Units	Type[b]	Base value for deterministic calculation	Source	Probabilistic Analysis[a]					Description
					Distribution	Parameter 1	Parameter 2	Parameter 3	Parameter 4	
Carbon-14 Data										
C-12 concentration in local water	g/cm3	P	2.00E-05	The base value is the default used in RESRAD-ONSITE code. It is assumed that this parameter has a triangular distribution, with the base value as the mode, the minimum being 1/10 of the base value, and the maximum being ten times of the base value.	Triangular	2.00E-06	2.00E-05	2.00E-04		The stable carbon concentration in water.
C-12 concentration in contaminated soil	g/g	P	3.00E-02	The base value is the default in DandD code for fraction of carbon in soil (Table 6.87 in NUREG/CR-5512, Volume 3). It is assumed that this parameter has a triangular distribution, with the base value as the mode, the minimum being 1/2 of the base value, and the maximum being two times the base value.	Triangular	1.50E-02	3.00E-02	6.00E-02		The stable carbon concentration in contaminated soil.
Fraction of vegetation carbon absorbed from soil	???	P	2.00E-02	The base value is the default in RESRAD-ONSITE code. It is assumed that this parameter has a triangular distribution, with the base value as the mode, the minimum being 1/2 of the base value, and the maximum being two times the base value.	Triangular	1.00E-02	2.00E-02	4.00E-02		The fraction of total vegetation carbon obtained by direct root uptake from the soil.
Fraction of vegetation carbon absorbed from air	????	P	9.80E-01	The base value is the default in RESRAD-ONSITE code. It is assumed that this parameter has a triangular distribution, with the base value as the mode, the minimum and maximum being determined by subtracting the maximum and minimum, respectively, of the previous parameter from 1.	Triangular	9.60E-01	9.80E-01	9.90E-01		The fraction of total vegetation carbon assimilated from the atmosphere through photosynthesis.

[a] For truncated lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution, parameter 3 = lower quantile, and parameter 4 = upper quantile; for lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution; for triangular distribution, parameter 1 = minimum, parameter 2 = mode or most likely, and parameter 3 = maximum; for truncated normal distribution, parameter 1 = mean, parameter 2 = standard deviation, parameter 3 = lower quantile, and parameter 4 = upper quantile; for bounded lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution, parameter 3 = minimum value, and parameter 4 = maximum value; for uniform distribution, parameter 1 = minimum, and parameter 2 = maximum; for continuous linear distribution, number of points, value of points, and cdf of points; for continuous logarithmic distribution, number of points, value of points, and cdf of points.

[b] P = physical, B= behavioral, and M = metabolic parameter.

[c] NR = not required.

[d] NA = not applicable.

Note: Density, porosity, and effective porosity are correlated. Correlations are used for uranium isotope Kd values in different zones.

Table B-2 Base Values and Statistical Distributions of Input Parameters Used in the RESRAD-ONSITE Code for the Resident Farmer Scenario Analysis (cont.)

Input Parameter	Units	Type[b]	Base value for deterministic calculation	Source	Probabilistic Analysis[a]					Description
					Distribution	Parameter 1	Parameter 2	Parameter 3	Parameter 4	
Carbon-14 Data (cont.)										
C-14 evasion layer thickness	m	P	3.00E-01	For deterministic calculation, the base value is the default in RESRAD-ONSITE. For probabilistic calculations, the statistical distribution from NUREG/CR-6697 is used.	Triangular	2.00E-01	3.00E-01	6.00E-01		The maximum soil thickness layer through which C-14 can escape to the air by conversion to CO_2. C-14 below this depth is assumed to be trapped.
C-14 evasion flux rate from soil	1/s	P	7.00E-07	The base value used is the default in RESRAD-ONSITE code. It is assumed that this parameter has a triangular distribution, with the base value as the mode, the minimum being 1/2 of the base value, and the maximum being two times the base value.	Triangular	3.50E-07	7.00E-07	1.40E-06		The fraction of soil inventory of C-14 that is lost to the atmosphere per unit time.
C-12 evasion flux rate from soil	1/s	P	1.00E-10	The base value is the default in RESRAD-ONSITE code. It is assumed that this parameter has a triangular distribution, with the base value as the mode, the minimum being 1/2 of the base, and the maximum being two times the base value.	Triangular	5.00E-11	1.00E-10	2.00E-10		The fraction of C-12 in soil that escapes to the atmosphere per unit time.
Grain fraction in livestock feed for beef cattle	???	B	1.00E-01	The base value is the default in DandD code for grain, forage, and hay intake of beef cattle (Table 6.87 in NUREG/CR-5512, Volume 3). It is assumed that this parameter has a triangular distribution, with the base value as the mode, and the minimum and the maximum being 1/2 and two times, respectively, the base value.	Triangular	5.00E-02	1.00E-01	2.00E-01		The fraction of grain (non-leafy) vegetation in the livestock diet. The balance is assumed to be leafy vegetation: hay or fodder.

[a] For truncated lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution, parameter 3 = lower quantile, and parameter 4 = upper quantile; for lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution; for triangular distribution, parameter 1 = minimum, parameter 2 = mode or most likely, and parameter 3 = maximum; for truncated normal distribution, parameter 1 = mean, parameter 2 = standard deviation, parameter 3 = lower quantile, and parameter 4 = upper quantile; for bounded lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution, parameter 3 = minimum value, and parameter 4 = maximum value; for uniform distribution, parameter 1 = minimum, and parameter 2 = maximum; for continuous linear distribution, number of points, value of points, and cdf of points; for continuous logarithmic distribution, number of points, value of points, and cdf of points.

[b] P = physical, B= behavioral, and M = metabolic parameter.

[c] NR = not required.

[d] NA = not applicable.

Note: Density, porosity, and effective porosity are correlated. Correlations are used for uranium isotope Kd values in different zones.

Table B-2 Base Values and Statistical Distributions of Input Parameters Used in the RESRAD-ONSITE Code for the Resident Farmer Scenario Analysis (cont.)

Input Parameter	Units	Type[b]	Base value for deterministic calculation	Source	Probabilistic Analysis[a]					Description
					Distribution	Parameter 1	Parameter 2	Parameter 3	Parameter 4	
Carbon-14 Data (cont.)										
Grain fraction in livestock feed for milk cow	???	B	3.00E-02	The base value is the default in DandD code for grain, forage, and hay intake of milk cow (Table 6.87 in NUREG/CR-5512, Volume 3). It is assumed that this parameter has a triangular distribution, with the base value as the mode, and the minimum and the maximum being 1/2 and two times, respectively, the base value.	Triangular	1.50E-02	3.00E-02	6.00E-02		The fraction of grain (non-leafy) vegetation in the livestock diet. The balance is assumed to be leafy vegetation: hay or fodder.
Dose Conversion Factors The code has radionuclide transformation based on ICRP 107 as well as on ICRP 38. For radionuclide transformation based on ICRP 107, the dose coefficients are from DCFPAK 3.02. For radionuclide transformation based on ICRP 38, the dose coefficients are available from ICRP 30 methodology (FGR 11 and FGR 12) and ICRP 60 methodology (ICRP 72 and FGR 13).										
Inhalation dose conversion factors	mrem/pCi	M	nuclide specific	Values from DCFPAK 3.02 for adult member of the public	NO	NR	NR	NR	NR	Dose conversion factors and slope factors are radionuclide dependent. Usually values for more than one inhalation class are listed. The three classes in FGR 11, D, W, and Y, correspond to retention half-times of less than 10 days, 10 to 100 days, and greater than 100 days; respectively. For some gaseous radionuclides (e.g., H-3, C-14, Ni-59, and Ni-63), inhalation classes other than D, W, Y are also listed. The most conservative dose conversion factor is chosen as the default. The values can be changed if chemical forms are known or more appropriate data are available.

[a] For truncated lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution, parameter 3 = lower quantile, and parameter 4 = upper quantile; for lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution; for triangular distribution, parameter 1 = minimum, parameter 2 = mode or most likely, and parameter 3 = maximum; for truncated normal distribution, parameter 1 = mean, parameter 2 = standard deviation, parameter 3 = lower quantile, and parameter 4 = upper quantile; for bounded lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution, parameter 3 = minimum value, and parameter 4 = maximum value; for uniform distribution, parameter 1 = minimum, and parameter 2 = maximum; for continuous linear distribution, number of points, value of points, and cdf of points; for continuous logarithmic distribution, number of points, value of points, and cdf of points.

[b] P = physical, B= behavioral, and M = metabolic parameter.

[c] NR = not required.

[d] NA = not applicable.

Note: Density, porosity, and effective porosity are correlated. Correlations are used for uranium isotope Kd values in different zones.

Table B-2 Base Values and Statistical Distributions of Input Parameters Used in the RESRAD-ONSITE Code for the Resident Farmer Scenario Analysis (cont.)

Input Parameter	Units	Type[b]	Base value for deterministic calculation	Source	Probabilistic Analysis[a]					Description
					Distribution	Parameter 1	Parameter 2	Parameter 3	Parameter 4	
Dose Conversion Factors (cont.)										
Ingestion dose conversion factors	mrem/pCi	M	nuclide specific	Values from DCFPAK 3.02 for adult member of the public	NO	NR	NR	NR	NR	Ingestion dose conversion factors depend on the chemical form, which determines the fraction of a radionuclide entering the gastrointestinal tract that reaches body fluids. The RESRD-ONSITE code lists this fraction along with the dose conversion factor. When more than one fraction and dose conversion factor are listed, the most conservative values are chosen as the default. The values can be changed if chemical forms are known or more appropriate data are available.
External dose conversion factors	mrem/yr per pCi/g	M	nuclide specific	Values from DCFPAK 3.02 for adult member of the public	NO	NR	NR	NR	NR	
Slope factor – external	risk/yr per pCi/g	M	nuclide specific	Values from DCFPAK 3.02 for adult member of the public	NO	NR	NR	NR	NR	The probability of developing a cancer per year of exposure to contaminated soil with 1 pCi/g of radionuclide concentration. The slope factors are developed based on the EPA methodology of calculating cancer risk.
Slope factor – inhalation	risk/pCi	M	nuclide specific	Values from DCFPAK 3.02 for adult member of the public	NO	NR	NR	NR	NR	The probability of developing a cancer by inhaling 1 pCi of radioactivity.
Slope factor – food ingestion	risk/pCi	M	nuclide specific	Values from DCFPAK 3.02 for adult member of the public	NO	NR	NR	NR	NR	The probability of developing a cancer by ingesting 1 pCi of radioactivity.through food intake
Slope factor – water ingestion	risk/pCi	M	nuclide specific	Values from DCFPAK 3.02 for adult member of the public	NO	NR	NR	NR	NR	The probability of developing a cancer by ingesting 1 pCi of radioactivity.through water intake
Slope factor – soil ingestion	risk/pCi	M	nuclide specific	Values from DCFPAK 3.02 for adult member of the public	NO	NR	NR	NR	NR	The probability of developing a cancer by ingesting 1 pCi of radioactivity.through soil intake

[a] For truncated lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution, parameter 3 = lower quantile, and parameter 4 = upper quantile; for lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution; for triangular distribution, parameter 1 = minimum, parameter 2 = mode or most likely, and parameter 3 = maximum; for truncated normal distribution, parameter 1 = mean, parameter 2 = standard deviation, parameter 3 = lower quantile, and parameter 4 = upper quantile; for bounded lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution, parameter 3 = minimum value, and parameter 4 = maximum value; for uniform distribution, parameter 1 = minimum, and parameter 2 = maximum; for continuous linear distribution, number of points, value of points, and cdf of points; for continuous logarithmic distribution, number of points, value of points, and cdf of points.

[b] P = physical, B= behavioral, and M = metabolic parameter.

[c] NR = not required.

[d] NA = not applicable.

Note: Density, porosity, and effective porosity are correlated. Correlations are used for uranium isotope Kd values in different zones.

Table B-3 Base Values and Distribution Parameters for Plant Transfer Factors Used in RESRAD-ONSITE and RESRAD-OFFSITE Analysis (pCi/g plant per pCi/g soil)

Nuclide	Base Value for Deterministic Calculation	Probabilistic Analysis[a]			
		Parameter 1	Parameter 2	Parameter 3	Parameter 4
Ac-227+D	1.00E-03	-6.90E+00	1.10E+00	1.00E-03	9.99E-01
C-14	7.00E-01	-4.00E-01	9.00E-01	0.00E+00	0.00E+00
Co-60	8.00E-02	-2.50E+00	9.00E-01	0.00E+00	0.00E+00
Cs-137	4.00E-02	-3.20E+00	1.00E+00	0.00E+00	0.00E+00
H-3	5.00E+00	1.60E+00	1.10E+00	0.00E+00	0.00E+00
I-129	2.00E-02	-3.90E+00	9.00E-01	1.00E-03	9.99E-01
Np-237+D	2.00E-02	-3.90E+00	9.00E-01	1.00E-03	9.99E-01
Pa-231	1.00E-02	-4.60E+00	1.10E+00	1.00E-03	9.99E-01
Pb-210+D	4.00E-03	-5.50E+00	9.00E-01	1.00E-03	9.99E-01
Po-210	1.00E-03	-6.90E+00	9.00E-01	1.00E-03	9.99E-01
Pu-239	1.00E-03	-6.90E+00	9.00E-01	1.00E-03	9.99E-01
Ra-226+D	4.00E-02	-3.20E+00	9.00E-01	1.00E-03	9.99E-01
Ra-228+D	4.00E-02	-3.20E+00	9.00E-01	1.00E-03	9.99E-01
Sr-90	3.00E-01	-1.20E+00	1.00E+00	0.00E+00	0.00E+00
Tc-99	5.00E+00	1.60E+00	9.00E-01	1.00E-03	9.99E-01
Th-228+D	1.00E-03	-6.90E+00	9.00E-01	1.00E-03	9.99E-01
Th-229+D	1.00E-03	-6.90E+00	9.00E-01	1.00E-03	9.99E-01
Th-230	1.00E-03	-6.90E+00	9.00E-01	1.00E-03	9.99E-01
U-233	2.00E-03	-6.20E+00	9.00E-01	1.00E-03	9.99E-01
U-234	2.00E-03	-6.20E+00	9.00E-01	1.00E-03	9.99E-01
U-235+D	2.00E-03	-6.20E+00	9.00E-01	1.00E-03	9.99E-01
U-238+D	2.00E-03	-6.20E+00	9.00E-01	1.00E-03	9.99E-01

[a] Plant transfer factor has truncated lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution, parameter 3 = lower quantile, and parameter 4 = upper quantile.

Table B-4 Base Values and Distribution Parameters for Meat Transfer Factors Used in RESRAD-ONSITE and RESRAD-OFFSITE Analysis (pCi/g per pCi/d)

Nuclide	Base Value for Deterministic Calculation	Probabilistic Analysis[a]			
		Parameter 1	Parameter 2	Parameter 3	Parameter 4
Ac-227+D	2.00E-05	-1.08E+01	1.00E+00	1.00E-03	9.99E-01
C-14	3.11E-02	-3.47E+00	1.00E+00	1.00E-03	9.99E-01
Co-60	4.31E-04	-7.75E+00	8.00E-01	1.00E-03	9.99E-01
Cs-137	2.19E-02	-3.82E+00	9.00E-01	1.00E-03	9.99E-01
H-3	1.20E-02	-4.42E+00	1.00E+00	1.00E-03	9.99E-01
I-129	6.67E-03	-5.01E+00	1.20E+00	1.00E-03	9.99E-01
Np-237+D	9.98E-04	-6.91E+00	7.00E-01	1.00E-03	9.99E-01
Pa-231	4.98E-06	-1.22E+01	1.00E+00	1.00E-03	9.99E-01
Pb-210+D	7.00E-04	-7.26E+00	9.00E-01	1.00E-03	9.99E-01
Po-210	4.99E-03	-5.30E+00	7.00E-01	1.00E-03	9.99E-01
Pu-239	1.10E-06	-1.37E+01	3.20E+00	1.00E-03	9.99E-01
Ra-226+D	9.98E-04	-6.91E+00	7.00E-01	1.00E-03	9.99E-01
Ra-228+D	9.98E-04	-6.91E+00	7.00E-01	1.00E-03	9.99E-01
Sr-90	1.29E-03	-6.65E+00	1.10E+00	0.00E+00	0.00E+00
Tc-99	1.00E-04	-9.21E+00	7.00E-01	1.00E-03	9.99E-01
Th-228+D	2.29E-04	-8.38E+00	1.10E+00	1.00E-03	9.99E-01
Th-229+D	2.29E-04	-8.38E+00	1.10E+00	1.00E-03	9.99E-01
Th-230	2.29E-04	-8.38E+00	1.10E+00	1.00E-03	9.99E-01
U-233	3.90E-04	-7.85E+00	5.00E-01	1.00E-03	9.99E-01
U-234	3.90E-04	-7.85E+00	5.00E-01	1.00E-03	9.99E-01
U-235+D	3.90E-04	-7.85E+00	5.00E-01	1.00E-03	9.99E-01
U-238+D	3.90E-04	-7.85E+00	5.00E-01	1.00E-03	9.99E-01

[a] Meat transfer factor has truncated lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution, parameter 3 = lower quantile, and parameter 4 = upper quantile.

Table B-5 Base Values and Distribution Parameters for Milk Transfer Factors Used in RESRAD-ONSITE and RESRAD-OFFSITE Analysis (pCi/L per pCi/d)

Nuclide	Base Value for Deterministic Calculation	Probabilistic Analysis[a]			
		Parameter 1	Parameter 2	Parameter 3	Parameter 4
Ac-227+D	2.00E-06	-1.31E+01	9.00E-01	1.00E-03	9.99E-01
C-14	1.23E-02	-4.40E+00	9.00E-01	1.00E-03	9.99E-01
Co-60	1.09E-04	-9.12E+00	7.00E-01	1.00E-03	9.99E-01
Cs-137	4.61E-03	-5.38E+00	7.00E-01	1.00E-03	9.99E-01
H-3	1.01E-02	-4.60E+00	9.00E-01	1.00E-03	9.99E-01
I-129	5.41E-03	-5.22E+00	9.00E-01	1.00E-03	9.99E-01
Np-237+D	1.00E-05	-1.15E+01	7.00E-01	1.00E-03	9.99E-01
Pa-231	4.98E-06	-1.22E+01	9.00E-01	1.00E-03	9.99E-01
Pb-210+D	3.01E-04	-8.11E+00	9.00E-01	1.00E-03	9.99E-01
Po-210	2.10E-04	-8.47E+00	6.00E-01	1.00E-03	9.99E-01
Pu-239	9.96E-07	-1.38E+01	5.00E-01	1.00E-03	9.99E-01
Ra-226+D	3.78E-04	-7.88E+00	8.00E-01	1.00E-03	9.99E-01
Ra-228+D	3.78E-04	-7.88E+00	8.00E-01	1.00E-03	9.99E-01
Sr-90	1.29E-03	-6.65E+00	5.00E-01	1.00E-03	9.99E-01
Tc-99	9.98E-04	-6.91E+00	7.00E-01	1.00E-03	9.99E-01
Th-228+D	4.98E-06	-1.22E+01	9.00E-01	1.00E-03	9.99E-01
Th-229+D	4.98E-06	-1.22E+01	9.00E-01	1.00E-03	9.99E-01
Th-230	4.98E-06	-1.22E+01	9.00E-01	1.00E-03	9.99E-01
U-233	1.80E-03	-6.32E+00	1.30E+00	1.00E-03	9.99E-01
U-234	1.80E-03	-6.32E+00	1.30E+00	1.00E-03	9.99E-01
U-235+D	1.80E-03	-6.32E+00	1.30E+00	1.00E-03	9.99E-01
U-238+D	1.80E-03	-6.32E+00	1.30E+00	1.00E-03	9.99E-01

[a] Milk transfer factor has truncated lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution, parameter 3 = lower quantile, and parameter 4 = upper quantile.

Table B-6 Base Values and Distribution Parameters for Fish Bioaccumulation Factors Used in RESRAD-ONSITE and RESRAD-OFFSITE Analysis (pCi/kg per pCi/L)

Nuclide	Base Value for Deterministic Calculation	Probabilistic Analysis[a]	
		Parameter 1	Parameter 2
Ac-227+D	2.45E+01	3.20E+00	1.10E+00
C-14	4.00E+05	1.29E+01	1.10E+00
Co-60	7.37E+01	4.30E+00	9.00E-01
Cs-137	2.44E+03	7.80E+00	9.00E-01
H-3	1.00E+00	0.00E+00	1.00E-01
I-129	3.00E+01	3.40E+00	9.00E-01
Np-237+D	2.01E+01	3.00E+00	1.10E+00
Pa-231	9.97E+00	2.30E+00	1.10E+00
Pb-210+D	2.45E+01	3.20E+00	1.10E+00
Po-210	3.66E+01	3.60E+00	1.50E+00
Pu-239	2.20E+04	1.00E+01	1.00E+00
Ra-226+D	4.06E+00	1.40E+00	1.90E+00
Ra-228+D	4.06E+00	1.40E+00	1.90E+00
Sr-90	3.00E+00	1.10E+00	1.40E+00
Tc-99	2.01E+01	3.00E+00	1.10E+00
Th-228+D	9.95E+01	4.60E+00	1.10E+00
Th-229+D	9.95E+01	4.60E+00	1.10E+00
Th-230	9.95E+01	4.60E+00	1.10E+00
U-233	1.00E+00	0.00E+00	2.50E+00
U-234	1.00E+00	0.00E+00	2.50E+00
U-235+D	1.00E+00	0.00E+00	2.50E+00
U-238+D	1.00E+00	0.00E+00	2.50E+00

[a] Fish transfer factor has lognormal distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution.

Table B-7 Base Values and Distribution Parameters for Crustacea Bioaccumulation Factors Used in RESRAD-ONSITE and RESRAD-OFFSITE Analysis (pCi/kg per pCi/L)

Nuclide	Base Value for Deterministic Calculation	Probabilistic Analysis[a]			
		Parameter 1	Parameter 2	Parameter 3	Parameter 4
Ac-227+D	1.00E+03	NR	NR	NR	NR
C-14	6.50E+04	NR	NR	NR	NR
Co-60	9.60E+02	NR	NR	NR	NR
Cs-137	1.00E+02	NR	NR	NR	NR
H-3	1.00E+00	NR	NR	NR	NR
I-129	1.00E+02	NR	NR	NR	NR
Np-237+D	9.50E+03	NR	NR	NR	NR
Pa-231	3.00E+01	NR	NR	NR	NR
Pb-210+D	2.30E+03	NR	NR	NR	NR
Po-210	1.10E+05	NR	NR	NR	NR
Pu-239	7.40E+03	NR	NR	NR	NR
Ra-226+D	1.40E+04	NR	NR	NR	NR
Ra-228+D	1.40E+04	NR	NR	NR	NR
Sr-90	3.50E+02	NR	NR	NR	NR
Tc-99	2.60E+01	NR	NR	NR	NR
Th-228+D	2.90E+03	NR	NR	NR	NR
Th-229+D	2.90E+03	NR	NR	NR	NR
Th-230	5.00E+02	NR	NR	NR	NR
U-233	5.40E+02	NR	NR	NR	NR
U-234	5.40E+02	NR	NR	NR	NR
U-235+D	5.40E+02	NR	NR	NR	NR
U-238+D	5.40E+02	NR	NR	NR	NR

[a] Distributions are not developed for crustacean bioaccumulation factor and probabilistic distribution parameters are not required.

Table B-8 Base Values and Distribution Parameters for K_ds Used in RESRAD-ONSITE and RESRAD-OFFSITE Analysis (cm^3/g)

Nuclide	Base Value for Deterministic Calculation	Probabilistic Analysis[a]			
		Parameter 1	Parameter 2	Parameter 3	Parameter 4
Ac-227+D	1.70E+03	7.44E+00	1.10E+00	1.00E-03	9.99E-01
C-14	1.10E+01	2.40E+00	3.22E+00	1.00E-03	9.99E-01
Co-60	4.80E+02	6.17E+00	2.77E+00	1.00E-03	9.99E-01
Cs-137	1.20E+03	7.09E+00	1.95E+00	1.00E-03	9.99E-01
H-3	6.02E-02	-2.81E+00	5.00E-01	1.00E-03	9.99E-01
I-129	7.00E+00	1.95E+00	1.61E+00	1.00E-03	9.99E-01
Np-237+D	3.60E+01	3.58E+00	1.79E+00	1.00E-03	9.99E-01
Pa-231	2.00E+03	7.60E+00	1.10E+00	1.00E-03	9.99E-01
Pb-210+D	2.10E+03	7.65E+00	2.30E+00	1.00E-03	9.99E-01
Po-210	1.80E+02	5.19E+00	1.61E+00	1.00E-03	9.99E-01
Pu-239	7.40E+02	6.61E+00	1.39E+00	1.00E-03	9.99E-01
Ra-226+D	2.50E+03	7.82E+00	2.56E+00	1.00E-03	9.99E-01
Ra-228+D	2.50E+03	7.82E+00	2.56E+00	1.00E-03	9.99E-01
Sr-90	5.20E+01	3.95E+00	1.79E+00	1.00E-03	9.99E-01
Tc-99	2.00E-01	-1.61E+00	2.20E+00	1.00E-03	9.99E-01
Th-228+D	1.90E+03	7.55E+00	2.30E+00	1.00E-03	9.99E-01
Th-229+D	1.90E+03	7.55E+00	2.30E+00	1.00E-03	9.99E-01
Th-230	1.90E+03	7.55E+00	2.30E+00	1.00E-03	9.99E-01
U-233	2.00E+02	5.30E+00	2.48E+00	1.00E-03	9.99E-01
U-234	2.00E+02	5.30E+00	2.48E+00	1.00E-03	9.99E-01
U-235+D	2.00E+02	5.30E+00	2.48E+00	1.00E-03	9.99E-01
U-238+D	2.00E+02	5.30E+00	2.48E+00	1.00E-03	9.99E-01

[a] K_d has truncated lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution, parameter 3 = lower quantile, and parameter 4 = upper quantile.

Table B-9 Parameter Correlations for Probabilistic Analyses

Parameter 1	Parameter 2	Correlation Coefficient	Comments
Area of contaminated zone	Length parallel to aquifer flow	0.95	The two parameters are strongly positively correlated
Fraction of vegetation carbon absorbed from air	Fraction of vegetation carbon absorbed from soil	-0.95	The two parameters are strongly negatively correlated
Contaminated zone soil density	Contaminated zone total porosity	-0.95	The two parameters are strongly negatively correlated.
Unsaturated zone soil density	Unsaturated zone total porosity	-0.95	The two parameters are strongly negatively correlated.
Unsaturated zone soil density	Unsaturated zone effective porosity	-0.95	The two parameters are strongly negatively correlated.
Saturated zone soil density	Saturated zone total porosity	-0.95	The two parameters are strongly negatively correlated.
Saturated zone soil density	Saturated zone effective porosity	-0.95	The two parameters are strongly negatively correlated.
Unsaturated zone total porosity	Unsaturated zone effective porosity	0.95	A correlation of 0.95 provides satisfactory pairing of sampling data.
Saturated zone total porosity	Saturated zone effective porosity	0.95	A correlation of 0.95 provides satisfactory pairing of sampling data.
K_d of U-234 in contaminated zone	K_d of U-238 in contaminated zone	0.95	The two parameters are strongly correlated.
K_d of U-234 in unsaturated zone	K_d of U-238 in unsaturated zone	0.95	The two parameters are strongly correlated.
K_d of U-234 in saturated zone	K_d of U-238 in saturated zone	0.95	The two parameters are strongly correlated.

B.1.2 Deterministic Results for Resident Farmer Scenario

Table B-10 presents the deterministic calculation dose results using the base values in Table B-2. The peak total dose for individual radionuclides varied from 1.38E-03 mrem/yr per pCi/g (H-3) to 6.63 mrem/yr per pCi/g (Ra-226). Unless all the pathway doses peaked at the same time, the sum of the peak pathway doses will exceed the peak all pathway dose. Any pathway with a peak dose that is more than 5 percent of the peak all pathway dose was considered significant in this analysis and is highlighted in Table B-10. For C-14 and I-129, the plant, meat, and milk ingestion pathways contributed significantly to the peak total dose. For Co-60 and Cs-137 direct external radiation was a dominant exposure pathway. For H-3, the plant, meat, milk, and inhalation pathways contributed significantly to the peak total dose. For Np-237 and Ra-228, direct external radiation and plant ingestion were two dominant exposure pathways. For Pu-239, inhalation, plant and soil ingestion were the two dominant exposure pathways. For Ra-226, direct external radiation, Ra-222 inhalation, and plant ingestion were dominant exposure pathways. For Sr-90 and Tc-99, the peak total dose was dominated by the contribution from plant and milk ingestion. For U-238, direct external radiation and milk ingestion were the two dominant exposure pathways.

B.1.3 Probabilistic Results for Resident Farmer Scenario

For each probabilistic analysis, input data sets were generated with the specifications of 2,000 observations, 3 repetitions, and the Latin Hypercube Sampling (LHS) technique. After the probabilistic calculations were completed, the dose results obtained with all input data sets were analyzed using the RESRAD-ONSITE code, and the average, minimum, maximum, and percentiles of the peak total dose and the peak pathway dose were reported. Table B-11 through B-22 list the reported results for the resident farmer scenario concerning soil contamination by each of the 12 radionuclides selected for evaluation. Any pathway with a p^{th} percentile dose that is more than 5 percent of the p^{th} percentile dose from all pathway was considered significant in this analysis and is highlighted in Tables B-11 through B-22.

Two variability criteria were used to analyze the results: ratio of peak dose at the 95 to 50 percentile and difference of peak dose at 95 percentile to peak dose at 50 percent are used. The ratio gives relative variability and the difference gives the absolute variability. The ratio and difference are in the last two rows of the dose distribution tables. Table B-23 presents the dominant exposure pathways identified in Tables B.11 through B.22 for dose percentiles 50 percent and 95 percent by radionuclide and compares it with dominant exposure pathways identified from deterministic analysis. In general, the probabilistic analysis tends to identify more dominant exposure pathways than the deterministic analysis because it considers all different possible combinations of various input parameter values.

B.1.4 Regression Analysis for Resident Farmer Scenario

The probabilistic analysis results were also used with the RESRAD-ONSITE code to identify input parameters with which the potential radiation dose is highly correlated. Regression analyses were performed to calculate four different correlation coefficients for each input parameter which are tabulated in the “linear regression” report. The input parameters are ranked according to their relative importance and their contribution to the overall uncertainty. The correlating statistical data provided include partial correlation coefficients (PCCs), standardized regression coefficients (SRCs), partial rank correlation coefficients (PRCCs), and the standardized rank regression coefficient (SRRC), as well as their associated correlation ranks. The correlation ranking of the parameters is based on the absolute value of the correlation coefficients: rank 1 is assigned to the parameter with the highest value. Thus, a parameter with a correlation rank of 1 has the strongest relationship with the total dose. The correlation rank is set to 0 in the code if the correlation of the resultant doses is 0, or if the resulting correlation matrix is singular. The PCC is calculated in the code by using the actual values of the input parameter and the resultant dose. It provides a measure of the linear relationship between the input parameter and the dose. The SRC is calculated by using the standardized values (i.e., [actual value-mean]/standard deviation) of the input parameter and the dose. It provides a direct measure of the relative importance of the input parameter independent of the units being used to measure the different parameters.

When nonlinear relationships are involved, it is advisable to calculate SRCs and PCCs on parameter ranks than on the actual values for the parameters; such coefficients are the SRRCs and PRCCs. The smallest value of each parameter is assigned rank 1, the next smallest value is assigned rank 2, and so on up to the largest value, which is assigned rank n, where n denotes the number of samples. The standardized regression coefficients and partial correlation coefficients are then calculated on these ranks. In general, use of PRCC and SRRC is recommended over PCC and SRC when nonlinear relationships are involved as is the case here. For identifying parameters that impact the peak total dose, a cut-off value of 0.05 was subjectively selected for the SRRC, judging by the range of SRRC from all input parameters. The selection of a low cut-off value will allow more input parameters to be identified that influence dose. Table B-24 summarizes the regression analysis results for the resident farmer scenario. The influence of a parameter is categorized subjectively into three groups: SRRC >0.2 (high influence on dose), SRRC in the range ≥0.1 to 0.2 (medium influence on dose), and SRRC in the range ≥0.05 to <0.1 (low influence on dose). The SRRC cutoff value and its range for categorizing input parameters are not absolute; they depend on the regression analysis results of each run and should be judged by the analyst.

The parameters for each radionuclide as listed in Table B-24 match the dominant exposure pathways identified previously. These parameters are used in modeling the radiation dose associated with the dominant exposure pathways, thereby influencing the total dose.

Table B-10 Peak Total Dose and Dose Contributions from Individual Pathways Obtained with Deterministic Calculations for the Resident Farmer Scenario for Soil Contamination by Each Radionuclide Selected for Evaluation (mrem/yr per pCi/g)

Radionuclide	Total	Water-independent Pathways							Water-dependent Pathways				
		Ground	Inhalation	Radon	Plant	Meat	Milk	Soil	Water	Fish	Plant	Meat	Milk
C-14	5.59E-02	2.31E-07	3.11E-06	0.00E+00	2.34E-02	2.06E-02	1.19E-02	1.40E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Co-60	5.39E+00	5.38E+00	8.14E-07	0.00E+00	8.77E-03	2.15E-04	2.55E-04	1.68E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Cs-137	1.40E+00	1.27E+00	1.10E-06	0.00E+00	1.84E-02	5.55E-02	6.24E-02	7.03E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
H-3	1.38E-03	0.00E+00	1.03E-04	0.00E+00	5.13E-04	1.09E-04	6.51E-04	2.54E-07	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
I-129	4.42E-01	4.18E-03	2.57E-06	0.00E+00	7.00E-02	8.69E-02	2.76E-01	5.23E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Np-237	5.57E-01	4.62E-01	1.38E-03	0.00E+00	7.36E-02	1.37E-02	5.37E-04	5.56E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Pu-239	2.56E-02	1.24E-04	3.37E-03	0.00E+00	8.81E-03	3.32E-05	1.08E-04	1.31E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Ra-226	6.63E+00	3.95E+00	2.74E-04	2.16E+00	3.98E-01	4.13E-02	6.59E-02	1.62E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Ra-228	4.04E+00	3.05E+00	9.18E-04	5.26E-02	7.15E-01	7.22E-02	1.12E-01	3.02E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Sr-90	3.93E-01	1.77E-02	4.36E-04	0.00E+00	3.04E-01	9.73E-03	5.98E-02	1.55E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Tc-99	4.63E-02	1.77E-05	1.32E-07	0.00E+00	4.08E-02	7.33E-05	5.44E-03	1.18E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
U-238	1.12E-01	6.62E-02	2.27E-04	1.01E-15	3.36E-03	2.26E-03	3.77E-02	2.51E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00

Note: Any pathway with a peak dose that is more than 5 percent of the peak total dose is highlighted.

Table B-11 Distributions of Peak Total Dose and Peak Pathway Dose Obtained with Probabilistic Calculations for the Resident Farmer Scenario for Soil Contamination by C-14 (mrem/yr per pCi/g)

Percentile	Peak total dose	Water-independent pathways							Water-dependent pathways					
		External ground	Inhalation	Radon	Plant ingestion	Meat ingestion	Milk ingestion	Soil ingestion	Water ingestion	Fish ingestion	Radon	Plant ingestion	Meat ingestion	Milk ingestion
5	1.07E-01	1.08E-07	5.02E-06	0.00E+00	4.51E-02	3.87E-02	2.20E-02	9.74E-07	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
10	1.53E-01	1.35E-07	7.25E-06	0.00E+00	6.58E-02	5.29E-02	3.22E-02	1.26E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
15	1.93E-01	1.66E-07	9.57E-06	0.00E+00	8.44E-02	6.55E-02	4.17E-02	1.52E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
20	2.38E-01	1.95E-07	1.17E-05	0.00E+00	1.06E-01	7.62E-02	5.26E-02	1.82E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
25	2.84E-01	2.29E-07	1.40E-05	0.00E+00	1.29E-01	8.85E-02	6.33E-02	2.17E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
30	3.26E-01	2.63E-07	1.63E-05	0.00E+00	1.51E-01	1.00E-01	7.35E-02	2.49E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
35	3.71E-01	2.99E-07	1.89E-05	0.00E+00	1.75E-01	1.11E-01	8.38E-02	2.87E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
40	4.20E-01	3.46E-07	2.16E-05	0.00E+00	2.00E-01	1.22E-01	9.58E-02	3.24E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
45	4.68E-01	3.89E-07	2.45E-05	0.00E+00	2.27E-01	1.33E-01	1.07E-01	3.65E-06	1.49E-08	3.42E-05	0.00E+00	3.03E-09	7.97E-09	5.19E-09
50	5.11E-01	4.39E-07	2.75E-05	0.00E+00	2.50E-01	1.45E-01	1.17E-01	4.13E-06	5.82E-08	5.70E-05	0.00E+00	1.26E-08	2.84E-08	2.03E-08
55	5.62E-01	4.96E-07	3.05E-05	0.00E+00	2.79E-01	1.56E-01	1.29E-01	4.64E-06	1.38E-07	8.37E-05	0.00E+00	2.80E-08	7.34E-08	5.04E-08
60	6.16E-01	5.58E-07	3.42E-05	0.00E+00	3.08E-01	1.68E-01	1.41E-01	5.18E-06	2.74E-07	1.16E-04	0.00E+00	6.05E-08	1.48E-07	9.72E-08
65	6.81E-01	6.24E-07	3.83E-05	0.00E+00	3.43E-01	1.83E-01	1.55E-01	5.78E-06	5.06E-07	1.57E-04	0.00E+00	1.06E-07	2.77E-07	1.85E-07
70	7.57E-01	6.93E-07	4.29E-05	0.00E+00	3.82E-01	2.00E-01	1.72E-01	6.41E-06	9.28E-07	2.08E-04	0.00E+00	1.98E-07	5.00E-07	3.39E-07
75	8.36E-01	7.71E-07	4.90E-05	0.00E+00	4.30E-01	2.19E-01	1.89E-01	7.11E-06	1.70E-06	2.76E-04	0.00E+00	3.83E-07	9.25E-07	6.26E-07
80	9.40E-01	8.63E-07	5.60E-05	0.00E+00	4.82E-01	2.43E-01	2.14E-01	7.89E-06	3.03E-06	3.65E-04	0.00E+00	6.41E-07	1.56E-06	1.09E-06
85	1.06E+00	9.96E-07	6.42E-05	0.00E+00	5.52E-01	2.72E-01	2.40E-01	8.93E-06	5.18E-06	5.11E-04	0.00E+00	1.18E-06	2.79E-06	1.89E-06
90	1.21E+00	1.18E-06	7.58E-05	0.00E+00	6.30E-01	3.08E-01	2.74E-01	1.02E-05	9.80E-06	7.85E-04	0.00E+00	2.11E-06	5.22E-06	3.66E-06
95	1.46E+00	1.46E-06	9.63E-05	0.00E+00	7.64E-01	3.66E-01	3.30E-01	1.19E-05	1.97E-05	1.40E-03	0.00E+00	4.23E-06	1.07E-05	7.33E-06
Max	4.48E+00	4.85E-06	2.66E-04	0.00E+00	2.21E+00	1.23E+00	1.04E+00	1.95E-05	1.24E-04	5.36E-01	0.00E+00	4.73E-05	1.01E-04	6.31E-05
mean	6.13E-01	5.70E-07	3.60E-05	0.00E+00	3.08E-01	1.66E-01	1.39E-01	5.00E-06	3.47E-06	6.37E-04	0.00E+00	7.55E-07	1.95E-06	1.32E-06
95/50	2.85E+00	3.33E+00	3.51E+00	NA	3.05E+00	2.53E+00	2.82E+00	2.87E+00	3.38E+02	2.45E+01	NA	3.35E+02	3.77E+02	3.60E+02
95 - 50	9.46E-01	1.02E-06	6.88E-05	0.00E+00	5.14E-01	2.21E-01	2.13E-01	7.74E-06	1.96E-05	1.34E-03	0.00E+00	4.22E-06	1.07E-05	7.31E-06

Note: Any pathway with a 50th or 95th percentile peak dose that is more than 5 percent of the total peak dose of the same percentile is highlighted. Different colors are used in different rows.

Table B-12 Distributions of Peak Total Dose and Peak Pathway Dose Obtained with Probabilistic Calculations for the Resident Farmer Scenario for Soil Contamination by Co-60 (mrem/yr per pCi/g)

Percentile	Peak total dose	Water-independent pathways							Water-dependent pathways					
		External ground	Inhalation	Radon	Plant ingestion	Meat ingestion	Milk ingestion	Soil ingestion	Water ingestion	Fish ingestion	Radon	Plant ingestion	Meat ingestion	Milk ingestion
5	2.55E+00	2.46E+00	2.49E-07	0.00E+00	8.22E-03	1.12E-04	1.75E-04	1.25E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
10	2.78E+00	2.68E+00	3.20E-07	0.00E+00	1.36E-02	1.67E-04	2.56E-04	1.61E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
15	2.96E+00	2.84E+00	3.77E-07	0.00E+00	1.90E-02	2.20E-04	3.42E-04	1.67E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
20	3.12E+00	3.00E+00	4.33E-07	0.00E+00	2.44E-02	2.66E-04	4.25E-04	1.68E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
25	3.26E+00	3.15E+00	4.81E-07	0.00E+00	3.06E-02	3.18E-04	5.11E-04	1.69E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
30	3.42E+00	3.29E+00	5.38E-07	0.00E+00	3.68E-02	3.72E-04	6.05E-04	1.69E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
35	3.57E+00	3.44E+00	5.87E-07	0.00E+00	4.34E-02	4.30E-04	7.16E-04	1.69E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
40	3.73E+00	3.59E+00	6.38E-07	0.00E+00	5.11E-02	5.02E-04	8.41E-04	1.69E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
45	3.88E+00	3.75E+00	6.89E-07	0.00E+00	5.91E-02	5.72E-04	9.81E-04	1.69E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
50	4.04E+00	3.91E+00	7.46E-07	0.00E+00	6.88E-02	6.61E-04	1.14E-03	1.69E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
55	4.22E+00	4.09E+00	8.07E-07	0.00E+00	7.99E-02	7.59E-04	1.32E-03	1.69E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
60	4.42E+00	4.28E+00	8.78E-07	0.00E+00	9.29E-02	8.74E-04	1.53E-03	1.69E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
65	4.63E+00	4.51E+00	9.52E-07	0.00E+00	1.07E-01	1.02E-03	1.80E-03	1.69E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
70	4.88E+00	4.75E+00	1.03E-06	0.00E+00	1.26E-01	1.18E-03	2.13E-03	1.69E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
75	5.19E+00	5.03E+00	1.14E-06	0.00E+00	1.48E-01	1.43E-03	2.54E-03	1.69E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
80	5.52E+00	5.38E+00	1.25E-06	0.00E+00	1.79E-01	1.77E-03	3.13E-03	1.69E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
85	5.95E+00	5.83E+00	1.40E-06	0.00E+00	2.21E-01	2.27E-03	4.05E-03	1.69E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
90	6.56E+00	6.39E+00	1.62E-06	0.00E+00	2.87E-01	3.05E-03	5.40E-03	1.69E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
95	7.49E+00	7.37E+00	2.00E-06	0.00E+00	4.02E-01	4.82E-03	8.70E-03	1.69E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
max	1.10E+01	1.03E+01	7.57E-06	0.00E+0 0	3.50E+00	5.36E-02	4.98E-01	1.69E-04	3.63E-05	3.02E-06	0.00E+00	1.25E-06	6.09E-07	1.46E-07
mean	4.40E+00	4.27E+00	8.87E-07	0.00E+00	1.22E-01	1.38E-03	2.52E-03	1.64E-04	7.17E-09	1.70E-09	0.00E+00	2.66E-10	1.08E-10	3.42E-11
95/50	1.85E+00	1.89E+00	2.67E+00	NA	5.85E+00	7.29E+00	7.64E+00	1.00E+00	NA	NA	NA	NA	NA	NA
95 - 50	3.44E+00	3.47E+00	1.25E-06	0.00E+00	3.33E-01	4.16E-03	7.57E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00

Note: Any pathway with a 50th or 95th percentile peak dose that is more than 5 percent of the total peak dose of the same percentile is highlighted. Different colors are used in different rows.

Table B-13 Distributions of Peak Total Dose and Peak Pathway Dose Obtained with Probabilistic Calculations for the Resident Farmer Scenario for Soil Contamination by Cs-137 (mrem/yr per pCi/g)

Percentile	Peak total dose	Water-independent pathways							Water-dependent pathways					
		External ground	Inhalation	Radon	Plant ingestion	Meat ingestion	Milk ingestion	Soil ingestion	Water ingestion	Fish ingestion	Radon	Plant ingestion	Meat ingestion	Milk ingestion
5	7.79E-01	5.42E-01	3.37E-07	0.00E+00	1.61E-02	1.59E-02	2.16E-02	5.34E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
10	8.58E-01	5.88E-01	4.35E-07	0.00E+00	2.60E-02	2.34E-02	3.04E-02	7.04E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
15	9.33E-01	6.24E-01	5.13E-07	0.00E+00	3.65E-02	3.11E-02	3.89E-02	7.07E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
20	1.00E+00	6.57E-01	5.88E-07	0.00E+00	4.82E-02	3.87E-02	4.77E-02	7.08E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
25	1.06E+00	6.90E-01	6.55E-07	0.00E+00	6.09E-02	4.66E-02	5.64E-02	7.08E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
30	1.12E+00	7.22E-01	7.30E-07	0.00E+00	7.33E-02	5.37E-02	6.66E-02	7.08E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
35	1.19E+00	7.53E-01	7.96E-07	0.00E+00	8.83E-02	6.24E-02	7.79E-02	7.08E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
40	1.25E+00	7.87E-01	8.65E-07	0.00E+00	1.05E-01	7.21E-02	8.90E-02	7.08E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
45	1.32E+00	8.21E-01	9.34E-07	0.00E+00	1.22E-01	8.24E-02	1.03E-01	7.08E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
50	1.39E+00	8.58E-01	1.01E-06	0.00E+00	1.42E-01	9.44E-02	1.18E-01	7.08E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
55	1.46E+00	8.98E-01	1.09E-06	0.00E+00	1.65E-01	1.09E-01	1.36E-01	7.08E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
60	1.55E+00	9.38E-01	1.19E-06	0.00E+00	1.93E-01	1.26E-01	1.56E-01	7.08E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
65	1.65E+00	9.86E-01	1.29E-06	0.00E+00	2.31E-01	1.48E-01	1.84E-01	7.08E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
70	1.76E+00	1.04E+00	1.40E-06	0.00E+00	2.74E-01	1.74E-01	2.15E-01	7.08E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
75	1.88E+00	1.10E+00	1.54E-06	0.00E+00	3.22E-01	2.09E-01	2.59E-01	7.08E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
80	2.05E+00	1.18E+00	1.69E-06	0.00E+00	3.91E-01	2.54E-01	3.18E-01	7.08E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
85	2.28E+00	1.28E+00	1.89E-06	0.00E+00	4.88E-01	3.18E-01	4.12E-01	7.08E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
90	2.61E+00	1.41E+00	2.19E-06	0.00E+00	6.52E-01	4.34E-01	5.60E-01	7.08E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
95	3.36E+00	1.61E+00	2.70E-06	0.00E+00	9.76E-01	6.81E-01	8.62E-01	7.08E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
max	3.08E+01	2.25E+00	1.02E-05	0.00E+00	9.82E+00	1.66E+01	9.59E+00	7.08E-04	1.09E-06	1.20E-05	0.00E+00	3.04E-08	1.59E-07	8.18E-07
mean	1.67E+00	9.37E-01	1.20E-06	0.00E+00	2.79E-01	2.03E-01	2.52E-01	6.89E-04	1.84E-10	2.06E-09	0.00E+00	5.22E-12	2.72E-11	1.38E-10
95/50	2.41E+00	1.88E+00	2.67E+00	NA	6.88E+00	7.22E+00	7.28E+00	1.00E+00	NA	NA	NA	NA	NA	NA
95 - 50	1.97E+00	7.56E-01	1.69E-06	0.00E+00	8.34E-01	5.87E-01	7.44E-01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00

Note: Any pathway with a 50th or 95th percentile peak dose that is more than 5 percent of the total peak dose of the same percentile is highlighted. Different colors are used in different rows.

Table B-14 Distributions of Peak Total Dose and Peak Pathway Dose Obtained with Probabilistic Calculations for the Resident Farmer Scenario for Soil Contamination by H-3 (mrem/yr per pCi/g)

Percentile	Peak total dose	Water-independent pathways							Water-dependent pathways					
		External ground	Inhalation	Radon	Plant ingestion	Meat ingestion	Milk ingestion	Soil ingestion	Water ingestion	Fish ingestion	Radon	Plant ingestion	Meat ingestion	Milk ingestion
5	3.68E-03	0.00E+00	1.57E-04	0.00E+00	1.43E-03	2.49E-04	1.61E-03	3.03E-07	2.89E-08	7.00E-10	0.00E+00	2.81E-09	1.84E-09	7.78E-09
10	6.51E-03	0.00E+00	2.26E-04	0.00E+00	2.66E-03	4.19E-04	2.89E-03	4.41E-07	4.51E-07	1.11E-08	0.00E+00	4.10E-08	2.70E-08	1.17E-07
15	9.99E-03	0.00E+00	2.76E-04	0.00E+00	4.30E-03	6.27E-04	4.41E-03	5.70E-07	1.73E-06	3.56E-08	0.00E+00	1.50E-07	1.09E-07	4.63E-07
20	1.38E-02	0.00E+00	3.30E-04	0.00E+00	6.15E-03	8.60E-04	6.10E-03	7.00E-07	4.38E-06	7.61E-08	0.00E+00	3.98E-07	2.74E-07	1.20E-06
25	1.82E-02	0.00E+00	3.79E-04	0.00E+00	8.10E-03	1.12E-03	8.10E-03	8.06E-07	9.19E-06	1.28E-07	0.00E+00	8.28E-07	5.52E-07	2.48E-06
30	2.27E-02	0.00E+00	4.29E-04	0.00E+00	1.04E-02	1.37E-03	1.02E-02	9.14E-07	1.57E-05	1.91E-07	0.00E+00	1.40E-06	9.47E-07	4.14E-06
35	2.83E-02	0.00E+00	4.77E-04	0.00E+00	1.31E-02	1.68E-03	1.24E-02	1.02E-06	2.49E-05	2.62E-07	0.00E+00	2.30E-06	1.55E-06	6.68E-06
40	3.45E-02	0.00E+00	5.28E-04	0.00E+00	1.60E-02	2.02E-03	1.51E-02	1.11E-06	3.99E-05	3.41E-07	0.00E+00	3.70E-06	2.50E-06	1.09E-05
45	4.07E-02	0.00E+00	5.85E-04	0.00E+00	1.94E-02	2.35E-03	1.79E-02	1.18E-06	6.07E-05	4.47E-07	0.00E+00	5.64E-06	3.79E-06	1.66E-05
50	4.72E-02	0.00E+00	6.42E-04	0.00E+00	2.23E-02	2.64E-03	2.05E-02	1.25E-06	8.96E-05	5.73E-07	0.00E+00	8.41E-06	5.62E-06	2.42E-05
55	5.32E-02	0.00E+00	7.07E-04	0.00E+00	2.52E-02	2.98E-03	2.33E-02	1.32E-06	1.39E-04	7.19E-07	0.00E+00	1.29E-05	8.53E-06	3.70E-05
60	5.95E-02	0.00E+00	7.76E-04	0.00E+00	2.84E-02	3.36E-03	2.63E-02	1.38E-06	2.10E-04	9.19E-07	0.00E+00	2.00E-05	1.33E-05	5.72E-05
65	6.63E-02	0.00E+00	8.57E-04	0.00E+00	3.17E-02	3.74E-03	2.90E-02	1.44E-06	3.14E-04	1.13E-06	0.00E+00	2.89E-05	1.99E-05	8.44E-05
70	7.28E-02	0.00E+00	9.36E-04	0.00E+00	3.51E-02	4.15E-03	3.23E-02	1.51E-06	4.66E-04	1.39E-06	0.00E+00	4.28E-05	2.92E-05	1.27E-04
75	8.02E-02	0.00E+00	1.04E-03	0.00E+00	3.85E-02	4.62E-03	3.53E-02	1.56E-06	6.90E-04	1.77E-06	0.00E+00	6.58E-05	4.41E-05	1.90E-04
80	8.79E-02	0.00E+00	1.17E-03	0.00E+00	4.23E-02	5.18E-03	3.92E-02	1.62E-06	1.09E-03	2.30E-06	0.00E+00	1.02E-04	6.80E-05	2.92E-04
85	9.54E-02	0.00E+00	1.33E-03	0.00E+00	4.64E-02	5.82E-03	4.34E-02	1.69E-06	1.66E-03	3.07E-06	0.00E+00	1.60E-04	1.03E-04	4.49E-04
90	1.07E-01	0.00E+00	1.55E-03	0.00E+00	5.16E-02	6.62E-03	4.93E-02	1.75E-06	2.69E-03	4.39E-06	0.00E+00	2.65E-04	1.68E-04	7.51E-04
95	1.23E-01	0.00E+00	1.97E-03	0.00E+00	5.88E-02	7.85E-03	5.76E-02	1.82E-06	4.93E-03	7.82E-06	0.00E+00	4.85E-04	3.11E-04	1.38E-03
max	2.47E-01	0.00E+00	5.90E-03	0.00E+00	1.15E-01	1.93E-02	1.21E-01	2.02E-06	4.23E-02	2.21E-04	0.00E+00	4.12E-03	2.76E-03	1.25E-02
mean	5.28E-02	0.00E+00	8.01E-04	0.00E+00	2.50E-02	3.17E-03	2.37E-02	1.17E-06	9.16E-04	2.13E-06	0.00E+00	9.40E-05	5.76E-05	2.52E-04
95/50	2.60E+00	NA	3.07E+00	NA	2.64E+00	2.97E+00	2.81E+00	1.45E+00	5.51E+01	1.36E+01	NA	5.76E+01	5.54E+01	5.72E+01
95 - 50	7.56E-02	0.00E+00	1.33E-03	0.00E+00	3.66E-02	5.21E-03	3.71E-02	5.67E-07	4.84E-03	7.25E-06	0.00E+00	4.76E-04	3.06E-04	1.36E-03

Note: Any pathway with a 50th or 95th percentile peak dose that is more than 5 percent of the total peak dose of the same percentile is highlighted. Different colors are used in different rows.

Table B-15 Distributions of Peak Total Dose and Peak Pathway Dose Obtained with Probabilistic Calculations for the Resident Farmer Scenario for Soil Contamination by I-129 (mrem/yr per pCi/g)

Percentile	Peak total dose	Water-independent pathways							Water-dependent pathways					
		External ground	Inhalation	Radon	Plant ingestion	Meat ingestion	Milk ingestion	Soil ingestion	Water ingestion	Fish ingestion	Radon	Plant ingestion	Meat ingestion	Milk ingestion
5	4.34E-01	1.69E-03	8.25E-07	0.00E+00	7.06E-02	1.96E-02	1.17E-01	3.86E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
10	6.00E-01	1.86E-03	1.05E-06	0.00E+00	1.09E-01	3.16E-02	1.72E-01	4.82E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
15	7.57E-01	1.98E-03	1.24E-06	0.00E+00	1.54E-01	4.37E-02	2.25E-01	5.20E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
20	8.93E-01	2.08E-03	1.43E-06	0.00E+00	2.00E-01	5.71E-02	2.82E-01	5.38E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
25	1.04E+00	2.19E-03	1.60E-06	0.00E+00	2.49E-01	7.03E-02	3.37E-01	5.48E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
30	1.20E+00	2.30E-03	1.77E-06	0.00E+00	2.99E-01	8.52E-02	4.01E-01	5.53E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
35	1.35E+00	2.40E-03	1.93E-06	0.00E+00	3.59E-01	1.01E-01	4.65E-01	5.57E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
40	1.55E+00	2.51E-03	2.12E-06	0.00E+00	4.19E-01	1.20E-01	5.40E-01	5.60E-03	1.95E-04	1.75E-04	0.00E+00	7.78E-06	6.75E-06	4.56E-05
45	1.73E+00	2.62E-03	2.29E-06	0.00E+00	4.83E-01	1.42E-01	6.22E-01	5.62E-03	2.09E-03	1.15E-03	0.00E+00	8.76E-05	1.17E-04	5.57E-04
50	1.95E+00	2.73E-03	2.48E-06	0.00E+00	5.60E-01	1.66E-01	7.12E-01	5.63E-03	6.55E-03	2.49E-03	0.00E+00	3.01E-04	3.98E-04	1.88E-03
55	2.23E+00	2.86E-03	2.69E-06	0.00E+00	6.45E-01	1.96E-01	8.26E-01	5.65E-03	1.51E-02	4.52E-03	0.00E+00	7.07E-04	1.01E-03	4.31E-03
60	2.52E+00	2.99E-03	2.93E-06	0.00E+00	7.47E-01	2.34E-01	9.57E-01	5.66E-03	3.36E-02	7.25E-03	0.00E+00	1.62E-03	2.21E-03	9.57E-03
65	2.89E+00	3.14E-03	3.17E-06	0.00E+00	8.87E-01	2.75E-01	1.11E+00	5.66E-03	6.53E-02	1.11E-02	0.00E+00	3.16E-03	4.19E-03	1.89E-02
70	3.31E+00	3.32E-03	3.44E-06	0.00E+00	1.03E+00	3.29E-01	1.32E+00	5.67E-03	1.18E-01	1.65E-02	0.00E+00	5.79E-03	8.42E-03	3.68E-02
75	3.92E+00	3.51E-03	3.79E-06	0.00E+00	1.21E+00	4.10E-01	1.56E+00	5.67E-03	2.11E-01	2.53E-02	0.00E+00	1.11E-02	1.61E-02	6.78E-02
80	4.69E+00	3.75E-03	4.15E-06	0.00E+00	1.44E+00	5.05E-01	1.90E+00	5.68E-03	3.72E-01	3.78E-02	0.00E+00	1.96E-02	2.85E-02	1.21E-01
85	5.87E+00	4.07E-03	4.63E-06	0.00E+00	1.77E+00	6.57E-01	2.39E+00	5.68E-03	6.92E-01	5.88E-02	0.00E+00	3.48E-02	5.66E-02	2.28E-01
90	7.63E+00	4.48E-03	5.37E-06	0.00E+00	2.28E+00	9.19E-01	3.26E+00	5.68E-03	1.30E+00	1.00E-01	0.00E+00	6.86E-02	1.31E-01	4.69E-01
95	1.16E+01	5.17E-03	6.67E-06	0.00E+00	3.32E+00	1.47E+00	5.04E+00	5.69E-03	3.22E+00	2.27E-01	0.00E+00	1.90E-01	3.36E-01	1.28E+00
max	1.60E+02	7.33E-03	2.48E-05	0.00E+00	2.73E+01	2.43E+01	6.11E+01	5.69E-03	7.29E+01	1.91E+01	0.00E+00	5.54E+00	1.84E+01	7.45E+01
mean	3.57E+00	2.98E-03	2.95E-06	0.00E+00	9.95E-01	4.10E-01	1.47E+00	5.38E-03	6.34E-01	5.61E-02	0.00E+00	3.75E-02	8.71E-02	2.99E-01
95/50	5.95E+00	1.90E+00	2.69E+00	NA	5.92E+00	8.87E+00	7.07E+00	1.01E+00	4.92E+02	9.12E+01	NA	6.31E+02	8.44E+02	6.82E+02
95 - 50	9.64E+00	2.44E-03	4.19E-06	0.00E+00	2.76E+00	1.31E+00	4.32E+00	5.30E-05	3.22E+00	2.25E-01	0.00E+00	1.90E-01	3.36E-01	1.28E+00

Note: Any pathway with a 50th or 95th percentile peak dose that is more than 5 percent of the total peak dose of the same percentile is highlighted. Different colors are used in different rows.

Table B-16 Distributions of Peak Total Dose and Peak Pathway Dose Obtained with Probabilistic Calculations for the Resident Farmer Scenario for Soil Contamination by Np-237 (mrem/yr per pCi/g)

Percentile	Peak total dose	Water-independent pathways							Water-dependent pathways					
		External ground	Inhalation	Radon	Plant ingestion	Meat ingestion	Milk ingestion	Soil ingestion	Water ingestion	Fish ingestion	Radon	Plant ingestion	Meat ingestion	Milk ingestion
5	3.81E-01	1.88E-01	4.21E-04	0.00E+00	7.10E-02	6.36E-03	3.03E-04	4.21E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
10	4.48E-01	2.05E-01	5.58E-04	0.00E+00	1.16E-01	8.57E-03	4.14E-04	5.27E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
15	5.03E-01	2.17E-01	6.60E-04	0.00E+00	1.56E-01	1.05E-02	5.25E-04	5.53E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
20	5.57E-01	2.29E-01	7.58E-04	0.00E+00	2.01E-01	1.24E-02	6.23E-04	5.60E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
25	6.13E-01	2.41E-01	8.45E-04	0.00E+00	2.52E-01	1.42E-02	7.29E-04	5.63E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
30	6.72E-01	2.52E-01	9.32E-04	0.00E+00	3.01E-01	1.61E-02	8.40E-04	5.65E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
35	7.39E-01	2.63E-01	1.02E-03	0.00E+00	3.57E-01	1.82E-02	9.64E-04	5.66E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
40	8.09E-01	2.74E-01	1.11E-03	0.00E+00	4.20E-01	2.04E-02	1.09E-03	5.67E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
45	8.84E-01	2.87E-01	1.20E-03	0.00E+00	4.92E-01	2.25E-02	1.24E-03	5.67E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
50	9.63E-01	3.00E-01	1.28E-03	0.00E+00	5.73E-01	2.52E-02	1.40E-03	5.68E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
55	1.07E+00	3.13E-01	1.38E-03	0.00E+00	6.64E-01	2.81E-02	1.58E-03	5.68E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
60	1.18E+00	3.28E-01	1.49E-03	0.00E+00	7.82E-01	3.15E-02	1.78E-03	5.68E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
65	1.31E+00	3.44E-01	1.61E-03	0.00E+00	9.05E-01	3.53E-02	2.01E-03	5.68E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
70	1.49E+00	3.63E-01	1.75E-03	0.00E+00	1.05E+00	4.02E-02	2.29E-03	5.68E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
75	1.66E+00	3.85E-01	1.92E-03	0.00E+00	1.23E+00	4.62E-02	2.65E-03	5.68E-03	1.27E-04	4.80E-05	0.00E+00	6.06E-06	1.07E-06	3.22E-07
80	1.91E+00	4.12E-01	2.13E-03	0.00E+00	1.46E+00	5.38E-02	3.13E-03	5.69E-03	1.84E-03	9.79E-04	0.00E+00	9.24E-05	1.85E-05	2.64E-06
85	2.25E+00	4.45E-01	2.41E-03	0.00E+00	1.78E+00	6.40E-02	3.91E-03	5.69E-03	1.29E-02	3.30E-03	0.00E+00	6.54E-04	1.30E-04	1.02E-05
90	2.79E+00	4.92E-01	2.80E-03	0.00E+00	2.29E+00	8.09E-02	5.06E-03	5.69E-03	5.36E-02	9.09E-03	0.00E+00	2.44E-03	5.58E-04	4.08E-05
95	3.89E+00	5.65E-01	3.45E-03	0.00E+00	3.29E+00	1.11E-01	7.49E-03	5.69E-03	2.47E-01	2.97E-02	0.00E+00	1.39E-02	2.79E-03	1.77E-04
max	1.63E+01	7.90E-01	1.16E-02	0.00E+00	1.49E+01	1.18E+00	7.30E-02	5.69E-03	1.17E+01	2.74E+00	0.00E+00	1.25E+00	5.02E-01	1.36E-02
mean	1.41E+00	3.27E-01	1.52E-03	0.00E+00	9.92E-01	3.87E-02	2.36E-03	5.48E-03	8.30E-02	9.65E-03	0.00E+00	4.96E-03	1.22E-03	6.99E-05
95/50	4.04E+00	1.88E+00	2.68E+00	NA	5.75E+00	4.38E+00	5.36E+00	1.00E+00	NA	NA	NA	NA	NA	NA
95 - 50	2.93E+00	2.65E-01	2.16E-03	0.00E+00	2.72E+00	8.53E-02	6.10E-03	1.10E-05	2.47E-01	2.97E-02	0.00E+00	1.39E-02	2.79E-03	1.77E-04

Note: Any pathway with a 50th or 95th percentile peak dose that is more than 5 percent of the total peak dose of the same percentile is highlighted. Different colors are used in different rows.

Table B-17 Distributions of Peak Total Dose and Peak Pathway Dose Obtained with Probabilistic Calculations for the Resident Farmer Scenario for Soil Contamination by Pu-239 (mrem/yr per pCi/g)

Percentile	Peak total dose	Water-independent pathways							Water-dependent pathways					
		External ground	Inhalation	Radon	Plant ingestion	Meat ingestion	Milk ingestion	Soil ingestion	Water ingestion	Fish ingestion	Radon	Plant ingestion	Meat ingestion	Milk ingestion
5	2.50E-02	4.92E-05	1.05E-03	0.00E+00	8.45E-03	2.11E-07	5.13E-05	9.95E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
10	3.05E-02	5.33E-05	1.36E-03	0.00E+00	1.37E-02	6.44E-07	6.37E-05	1.32E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
15	3.64E-02	5.67E-05	1.60E-03	0.00E+00	1.85E-02	1.41E-06	7.39E-05	1.32E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
20	4.21E-02	5.99E-05	1.82E-03	0.00E+00	2.37E-02	2.69E-06	8.22E-05	1.32E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
25	4.79E-02	6.27E-05	2.01E-03	0.00E+00	2.93E-02	4.60E-06	9.09E-05	1.32E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
30	5.44E-02	6.59E-05	2.22E-03	0.00E+00	3.59E-02	7.28E-06	1.00E-04	1.32E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
35	6.18E-02	6.85E-05	2.45E-03	0.00E+00	4.28E-02	1.16E-05	1.08E-04	1.32E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
40	6.96E-02	7.16E-05	2.66E-03	0.00E+00	5.02E-02	1.69E-05	1.18E-04	1.32E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
45	7.77E-02	7.47E-05	2.88E-03	0.00E+00	5.83E-02	2.65E-05	1.27E-04	1.32E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
50	8.73E-02	7.80E-05	3.09E-03	0.00E+00	6.82E-02	3.94E-05	1.37E-04	1.32E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
55	9.84E-02	8.14E-05	3.33E-03	0.00E+00	7.84E-02	5.91E-05	1.49E-04	1.32E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
60	1.10E-01	8.53E-05	3.60E-03	0.00E+00	8.97E-02	8.78E-05	1.59E-04	1.32E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
65	1.26E-01	8.96E-05	3.90E-03	0.00E+00	1.04E-01	1.36E-04	1.72E-04	1.32E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
70	1.43E-01	9.43E-05	4.26E-03	0.00E+00	1.21E-01	2.04E-04	1.85E-04	1.32E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
75	1.65E-01	1.00E-04	4.68E-03	0.00E+00	1.43E-01	3.40E-04	2.02E-04	1.32E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
80	1.93E-01	1.07E-04	5.14E-03	0.00E+00	1.72E-01	5.72E-04	2.23E-04	1.32E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
85	2.35E-01	1.16E-04	5.78E-03	0.00E+00	2.11E-01	1.15E-03	2.48E-04	1.32E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
90	2.95E-01	1.28E-04	6.73E-03	0.00E+00	2.69E-01	2.43E-03	2.85E-04	1.32E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
95	4.14E-01	1.47E-04	8.26E-03	0.00E+00	3.84E-01	8.07E-03	3.41E-04	1.32E-02	2.03E-10	6.86E-12	0.00E+00	9.70E-12	7.77E-13	1.35E-11
max	4.93E+00	2.05E-04	2.72E-02	0.00E+00	4.10E+00	4.82E+00	9.94E-04	1.32E-02	1.09E-02	4.29E+00	0.00E+00	2.37E-04	1.29E-06	3.50E-07
mean	1.39E-01	8.51E-05	3.67E-03	0.00E+00	1.17E-01	5.03E-03	1.60E-04	1.29E-02	2.37E-06	1.01E-03	0.00E+00	6.23E-08	2.26E-10	3.95E-10
95/50	4.75E+00	1.89E+00	2.67E+00	NA	5.63E+00	2.05E+02	2.50E+00	1.00E+00	NA	NA	NA	NA	NA	NA
95 - 50	3.27E-01	6.93E-05	5.17E-03	0.00E+00	3.16E-01	8.03E-03	2.04E-04	0.00E+00	2.03E-10	6.86E-12	0.00E+00	9.70E-12	7.77E-13	1.35E-11

Note: Any pathway with a 50th or 95th percentile peak dose that is more than 5 percent of the total peak dose of the same percentile is highlighted. Different colors are used in different rows.

Table B-18 Distributions of Peak Total Dose and Peak Pathway Dose Obtained with Probabilistic Calculations for the Resident Farmer Scenario for Soil Contamination by Ra-226 (mrem/yr per pCi/g)

Percentile	Peak total dose	Water-independent pathways							Water-dependent pathways					
		External ground	Inhalation	Radon	Plant ingestion	Meat ingestion	Milk ingestion	Soil ingestion	Water ingestion	Fish ingestion	Radon	Plant ingestion	Meat ingestion	Milk ingestion
5	5.43E+00	1.79E+00	1.39E-04	2.39E-01	6.58E-01	7.51E-02	1.33E-01	3.96E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
10	6.66E+00	1.95E+00	1.82E-04	4.27E-01	1.03E+00	1.01E-01	1.85E-01	5.97E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
15	7.75E+00	2.07E+00	2.17E-04	6.34E-01	1.44E+00	1.26E-01	2.35E-01	7.67E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
20	8.76E+00	2.18E+00	2.51E-04	9.00E-01	1.90E+00	1.50E-01	2.78E-01	8.69E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
25	9.78E+00	2.28E+00	2.85E-04	1.20E+00	2.36E+00	1.74E-01	3.25E-01	9.50E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
30	1.09E+01	2.39E+00	3.14E-04	1.56E+00	2.83E+00	1.97E-01	3.71E-01	9.93E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
35	1.20E+01	2.50E+00	3.46E-04	1.93E+00	3.35E+00	2.18E-01	4.17E-01	1.02E-01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
40	1.32E+01	2.62E+00	3.77E-04	2.38E+00	3.91E+00	2.42E-01	4.73E-01	1.04E-01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
45	1.44E+01	2.72E+00	4.09E-04	2.93E+00	4.54E+00	2.70E-01	5.34E-01	1.05E-01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
50	1.57E+01	2.84E+00	4.44E-04	3.63E+00	5.26E+00	2.95E-01	6.01E-01	1.06E-01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
55	1.71E+01	2.97E+00	4.83E-04	4.48E+00	6.04E+00	3.26E-01	6.63E-01	1.07E-01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
60	1.88E+01	3.12E+00	5.22E-04	5.42E+00	6.73E+00	3.63E-01	7.45E-01	1.07E-01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
65	2.09E+01	3.27E+00	5.66E-04	6.47E+00	7.66E+00	4.09E-01	8.44E-01	1.08E-01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
70	2.31E+01	3.45E+00	6.17E-04	8.13E+00	8.78E+00	4.60E-01	9.69E-01	1.08E-01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
75	2.59E+01	3.66E+00	6.83E-04	1.02E+01	1.02E+01	5.16E-01	1.12E+00	1.08E-01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
80	2.95E+01	3.91E+00	7.51E-04	1.34E+01	1.17E+01	5.90E-01	1.30E+00	1.08E-01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
85	3.45E+01	4.22E+00	8.39E-04	1.75E+01	1.41E+01	6.86E-01	1.56E+00	1.08E-01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
90	4.23E+01	4.65E+00	9.78E-04	2.47E+01	1.72E+01	8.42E-01	1.99E+00	1.08E-01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
95	5.82E+01	5.38E+00	1.22E-03	4.15E+01	2.35E+01	1.13E+00	2.74E+00	1.08E-01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
max	4.84E+02	7.57E+00	4.22E-03	4.66E+02	1.73E+02	6.62E+00	1.50E+01	1.09E-01	2.67E-01	2.07E-02	1.83E-02	1.44E-02	2.65E-03	6.63E-03
mean	2.18E+01	3.11E+00	5.32E-04	1.01E+01	7.79E+00	4.16E-01	9.09E-01	9.54E-02	9.80E-05	5.26E-06	7.80E-06	6.93E-06	9.88E-07	2.42E-06
95/50	3.71E+00	1.89E+00	2.74E+00	1.14E+01	4.46E+00	3.81E+00	4.55E+00	1.02E+00	NA	NA	NA	NA	NA	NA
95 - 50	4.25E+01	2.54E+00	7.72E-04	3.79E+01	1.82E+01	8.30E-01	2.14E+00	2.30E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00

Note: Any pathway with a 50th or 95th percentile peak dose that is more than 5 percent of the total peak dose of the same percentile is highlighted. Different colors are used in different rows.

Table B-19 Distributions of Peak Total Dose and Peak Pathway Dose Obtained with Probabilistic Calculations for the Resident Farmer Scenario for Soil Contamination by Ra-228 (mrem/yr per pCi/g)

Percentile	Peak total dose	Water-independent pathways							Water-dependent pathways					
		External ground	Inhalation	Radon	Plant ingestion	Meat ingestion	Milk ingestion	Soil ingestion	Water ingestion	Fish ingestion	Radon	Plant ingestion	Meat ingestion	Milk ingestion
5	3.13E+00	1.43E+00	3.05E-04	2.79E-02	8.24E-01	4.86E-02	7.61E-02	2.71E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
10	3.80E+00	1.56E+00	3.87E-04	3.53E-02	1.37E+00	6.64E-02	1.14E-01	3.54E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
15	4.47E+00	1.65E+00	4.59E-04	4.11E-02	1.92E+00	8.25E-02	1.52E-01	3.57E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
20	5.12E+00	1.74E+00	5.22E-04	4.67E-02	2.53E+00	9.88E-02	1.89E-01	3.57E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
25	5.78E+00	1.83E+00	5.82E-04	5.20E-02	3.18E+00	1.15E-01	2.31E-01	3.57E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
30	6.46E+00	1.91E+00	6.46E-04	5.72E-02	3.85E+00	1.33E-01	2.66E-01	3.57E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
35	7.17E+00	2.00E+00	7.03E-04	6.23E-02	4.56E+00	1.51E-01	3.06E-01	3.57E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
40	7.94E+00	2.09E+00	7.68E-04	6.74E-02	5.27E+00	1.69E-01	3.54E-01	3.57E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
45	8.88E+00	2.18E+00	8.33E-04	7.24E-02	6.05E+00	1.89E-01	4.09E-01	3.57E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
50	9.94E+00	2.28E+00	9.03E-04	7.80E-02	7.14E+00	2.12E-01	4.71E-01	3.57E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
55	1.12E+01	2.38E+00	9.72E-04	8.46E-02	8.26E+00	2.38E-01	5.51E-01	3.57E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
60	1.27E+01	2.49E+00	1.05E-03	9.07E-02	9.56E+00	2.69E-01	6.41E-01	3.57E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
65	1.43E+01	2.62E+00	1.14E-03	9.80E-02	1.11E+01	3.07E-01	7.48E-01	3.57E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
70	1.63E+01	2.77E+00	1.25E-03	1.07E-01	1.29E+01	3.49E-01	8.84E-01	3.57E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
75	1.86E+01	2.94E+00	1.36E-03	1.16E-01	1.53E+01	4.05E-01	1.06E+00	3.57E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
80	2.20E+01	3.13E+00	1.51E-03	1.28E-01	1.81E+01	4.79E-01	1.30E+00	3.57E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
85	2.63E+01	3.39E+00	1.68E-03	1.43E-01	2.21E+01	5.77E-01	1.64E+00	3.57E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
90	3.29E+01	3.72E+00	1.92E-03	1.65E-01	2.85E+01	7.53E-01	2.22E+00	3.57E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
95	4.58E+01	4.30E+00	2.39E-03	2.05E-01	4.07E+01	1.14E+00	3.45E+00	3.57E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
max	2.65E+02	6.09E+00	8.13E-03	5.49E-01	2.15E+02	9.92E+00	5.17E+01	3.57E-02	4.20E-09	1.32E-09	1.41E-12	8.30E-11	4.72E-11	7.30E-11
mean	1.56E+01	2.49E+00	1.07E-03	9.15E-02	1.23E+01	3.58E-01	9.86E-01	3.47E-02	7.66E-13	3.08E-13	2.37E-16	1.79E-14	8.04E-15	1.55E-14
95/50	4.61E+00	1.89E+00	2.65E+00	2.63E+00	5.70E+00	5.38E+00	7.33E+00	1.00E+00	NA	NA	NA	NA	NA	NA
95 - 50	3.59E+01	2.02E+00	1.49E-03	1.27E-01	3.36E+01	9.27E-01	2.98E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00

Note: Any pathway with a 50th or 95th percentile peak dose that is more than 5 percent of the total peak dose of the same percentile is highlighted. Different colors are used in different rows.

Table B-20 Distributions of Peak Total Dose and Peak Pathway Dose Obtained with Probabilistic Calculations for the Resident Farmer Scenario for Soil Contamination by Sr-90 (mrem/yr per pCi/g)

Percentile	Peak total dose	Water-independent pathways							Water-dependent pathways					
		External ground	Inhalation	Radon	Plant ingestion	Meat ingestion	Milk ingestion	Soil ingestion	Water ingestion	Fish ingestion	Radon	Plant ingestion	Meat ingestion	Milk ingestion
5	3.48E-01	6.90E-03	1.34E-06	0.00E+00	2.54E-01	4.21E-03	4.84E-02	1.16E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
10	5.61E-01	7.52E-03	1.73E-06	0.00E+00	4.17E-01	7.34E-03	7.40E-02	1.48E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
15	7.74E-01	7.98E-03	2.03E-06	0.00E+00	5.93E-01	1.08E-02	1.02E-01	1.54E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
20	9.99E-01	8.41E-03	2.34E-06	0.00E+00	7.83E-01	1.44E-02	1.32E-01	1.56E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
25	1.25E+00	8.82E-03	2.60E-06	0.00E+00	9.90E-01	1.87E-02	1.61E-01	1.57E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
30	1.51E+00	9.25E-03	2.90E-06	0.00E+00	1.20E+00	2.29E-02	2.00E-01	1.57E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
35	1.78E+00	9.65E-03	3.16E-06	0.00E+00	1.42E+00	2.79E-02	2.38E-01	1.57E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
40	2.10E+00	1.01E-02	3.44E-06	0.00E+00	1.69E+00	3.46E-02	2.86E-01	1.57E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
45	2.45E+00	1.05E-02	3.72E-06	0.00E+00	1.97E+00	4.13E-02	3.38E-01	1.57E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
50	2.87E+00	1.10E-02	4.03E-06	0.00E+00	2.33E+00	5.04E-02	4.00E-01	1.57E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
55	3.34E+00	1.15E-02	4.36E-06	0.00E+00	2.73E+00	6.09E-02	4.70E-01	1.57E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
60	3.92E+00	1.20E-02	4.74E-06	0.00E+00	3.21E+00	7.41E-02	5.39E-01	1.58E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
65	4.65E+00	1.26E-02	5.13E-06	0.00E+00	3.72E+00	9.10E-02	6.43E-01	1.58E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
70	5.43E+00	1.33E-02	5.58E-06	0.00E+00	4.46E+00	1.12E-01	7.69E-01	1.58E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
75	6.54E+00	1.41E-02	6.15E-06	0.00E+00	5.31E+00	1.44E-01	9.46E-01	1.58E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
80	8.09E+00	1.51E-02	6.76E-06	0.00E+00	6.51E+00	1.91E-01	1.16E+00	1.58E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
85	1.01E+01	1.64E-02	7.51E-06	0.00E+00	8.26E+00	2.63E-01	1.50E+00	1.58E-03	1.66E-11	5.48E-13	0.00E+00	8.63E-13	2.11E-13	1.14E-12
90	1.35E+01	1.80E-02	8.75E-06	0.00E+00	1.09E+01	3.97E-01	2.07E+00	1.58E-03	2.74E-08	1.23E-09	0.00E+00	1.64E-09	3.10E-10	1.79E-09
95	1.98E+01	2.07E-02	1.08E-05	0.00E+00	1.61E+01	7.00E-01	3.20E+00	1.58E-03	8.70E-06	5.41E-07	0.00E+00	4.87E-07	1.18E-07	6.94E-07
max	3.30E+02	2.88E-02	4.08E-05	0.00E+00	1.73E+02	1.75E+01	1.64E+02	1.58E-03	1.13E-01	3.02E-03	0.00E+00	6.33E-03	2.23E-02	1.03E-02
mean	5.70E+00	1.20E-02	4.79E-06	0.00E+00	4.59E+00	1.78E-01	9.18E-01	1.52E-03	1.78E-04	4.11E-06	0.00E+00	1.10E-05	8.85E-06	1.47E-05
95/50	6.88E+00	1.88E+00	2.68E+00	NA	6.90E+00	1.39E+01	7.99E+00	1.00E+00	NA	NA	NA	NA	NA	NA
95 - 50	1.69E+01	9.68E-03	6.76E-06	0.00E+00	1.38E+01	6.50E-01	2.80E+00	2.00E-06	8.70E-06	5.41E-07	0.00E+00	4.87E-07	1.18E-07	6.94E-07

Note: Any pathway with a 50th or 95th percentile peak dose that is more than 5 percent of the total peak dose of the same percentile is highlighted. Different colors are used in different rows.

Table B-21 Distributions of Peak Total Dose and Peak Pathway Dose Obtained with Probabilistic Calculations for the Resident Farmer Scenario for Soil Contamination by Tc-99 (mrem/yr per pCi/g)

Percentile	Peak total dose	Water-independent pathways							Water-dependent pathways					
		External ground	Inhalation	Radon	Plant ingestion	Meat ingestion	Milk ingestion	Soil ingestion	Water ingestion	Fish ingestion	Radon	Plant ingestion	Meat ingestion	Milk ingestion
5	7.94E-02	1.26E-05	8.11E-08	0.00E+00	6.50E-02	8.52E-05	6.98E-03	1.25E-05	4.66E-06	3.41E-06	0.00E+00	5.53E-07	3.49E-09	2.56E-07
10	1.44E-01	1.57E-05	1.10E-07	0.00E+00	1.17E-01	1.55E-04	1.20E-02	1.73E-05	7.09E-05	3.24E-05	0.00E+00	1.15E-05	7.27E-08	3.98E-06
15	2.02E-01	1.75E-05	1.35E-07	0.00E+00	1.69E-01	2.38E-04	1.77E-02	2.06E-05	2.19E-04	7.38E-05	0.00E+00	3.28E-05	2.33E-07	1.22E-05
20	2.74E-01	1.89E-05	1.56E-07	0.00E+00	2.30E-01	3.17E-04	2.47E-02	2.32E-05	4.38E-04	1.24E-04	0.00E+00	7.11E-05	4.83E-07	2.77E-05
25	3.51E-01	2.01E-05	1.77E-07	0.00E+00	2.91E-01	4.04E-04	3.28E-02	2.51E-05	8.74E-04	1.83E-04	0.00E+00	1.36E-04	9.28E-07	5.05E-05
30	4.30E-01	2.12E-05	1.96E-07	0.00E+00	3.60E-01	5.10E-04	4.16E-02	2.65E-05	1.44E-03	2.59E-04	0.00E+00	2.24E-04	1.63E-06	8.34E-05
35	5.21E-01	2.24E-05	2.20E-07	0.00E+00	4.41E-01	6.22E-04	5.16E-02	2.76E-05	2.26E-03	3.40E-04	0.00E+00	3.61E-04	2.46E-06	1.41E-04
40	6.13E-01	2.35E-05	2.43E-07	0.00E+00	5.21E-01	7.46E-04	6.29E-02	2.85E-05	3.42E-03	4.49E-04	0.00E+00	5.64E-04	3.73E-06	2.15E-04
45	7.21E-01	2.47E-05	2.65E-07	0.00E+00	6.10E-01	8.95E-04	7.59E-02	2.92E-05	5.23E-03	5.82E-04	0.00E+00	8.50E-04	5.65E-06	3.19E-04
50	8.41E-01	2.60E-05	2.87E-07	0.00E+00	7.18E-01	1.08E-03	9.07E-02	2.98E-05	7.48E-03	7.52E-04	0.00E+00	1.27E-03	8.37E-06	4.88E-04
55	9.78E-01	2.73E-05	3.13E-07	0.00E+00	8.42E-01	1.28E-03	1.07E-01	3.04E-05	1.07E-02	9.75E-04	0.00E+00	1.84E-03	1.21E-05	7.06E-04
60	1.15E+00	2.87E-05	3.41E-07	0.00E+00	9.89E-01	1.54E-03	1.29E-01	3.09E-05	1.59E-02	1.24E-03	0.00E+00	2.66E-03	1.79E-05	1.02E-03
65	1.33E+00	3.03E-05	3.73E-07	0.00E+00	1.15E+00	1.86E-03	1.52E-01	3.14E-05	2.24E-02	1.60E-03	0.00E+00	3.84E-03	2.59E-05	1.50E-03
70	1.57E+00	3.20E-05	4.06E-07	0.00E+00	1.34E+00	2.24E-03	1.87E-01	3.18E-05	3.12E-02	2.07E-03	0.00E+00	5.60E-03	3.76E-05	2.06E-03
75	1.85E+00	3.41E-05	4.45E-07	0.00E+00	1.59E+00	2.72E-03	2.29E-01	3.22E-05	4.68E-02	2.73E-03	0.00E+00	8.14E-03	5.54E-05	3.00E-03
80	2.29E+00	3.62E-05	4.93E-07	0.00E+00	1.97E+00	3.49E-03	2.89E-01	3.26E-05	6.69E-02	3.79E-03	0.00E+00	1.18E-02	8.30E-05	4.54E-03
85	2.79E+00	3.94E-05	5.53E-07	0.00E+00	2.41E+00	4.57E-03	3.75E-01	3.30E-05	9.86E-02	5.27E-03	0.00E+00	1.78E-02	1.28E-04	6.96E-03
90	3.68E+00	4.39E-05	6.37E-07	0.00E+00	3.13E+00	6.29E-03	5.21E-01	3.33E-05	1.57E-01	8.21E-03	0.00E+00	2.84E-02	2.02E-04	1.14E-02
95	5.28E+00	5.08E-05	8.03E-07	0.00E+00	4.50E+00	1.03E-02	8.33E-01	3.36E-05	2.69E-01	1.56E-02	0.00E+00	5.59E-02	4.07E-04	2.14E-02
max	9.10E+01	7.95E-05	2.84E-06	0.00E+00	4.00E+01	1.28E-01	5.30E+01	3.38E-05	2.02E+00	2.65E-01	0.00E+00	6.06E-01	9.15E-03	3.12E-01
mean	1.56E+00	2.81E-05	3.44E-07	0.00E+00	1.32E+00	2.68E-03	2.31E-01	2.75E-05	5.36E-02	3.82E-03	0.00E+00	1.13E-02	7.98E-05	4.34E-03
95/50	6.28E+00	1.95E+00	2.79E+00	NA	6.27E+00	9.56E+00	9.18E+00	1.13E+00	3.60E+01	2.08E+01	NA	4.41E+01	4.86E+01	4.38E+01
95 - 50	4.44E+00	2.48E-05	5.15E-07	0.00E+00	3.78E+00	9.20E-03	7.43E-01	3.80E-06	2.62E-01	1.49E-02	0.00E+00	5.46E-02	3.99E-04	2.09E-02

Note: Any pathway with a 50th or 95th percentile peak dose that is more than 5 percent of the total peak dose of the same percentile is highlighted. Different colors are used in different rows.

Table B-22 Distributions of Peak Total Dose and Peak Pathway Dose Obtained with Probabilistic Calculations for the Resident Farmer Scenario for Soil Contamination by U-238 (mrem/yr per pCi/g)

Percentile	Peak total dose	Water-independent pathways							Water-dependent pathways					
		External ground	Inhalation	Radon	Plant ingestion	Meat ingestion	Milk ingestion	Soil ingestion	Water ingestion	Fish ingestion	Radon	Plant ingestion	Meat ingestion	Milk ingestion
5	6.57E-02	2.78E-02	6.92E-05	8.47E-11	3.01E-03	1.02E-03	5.35E-03	1.86E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
10	7.65E-02	3.03E-02	9.07E-05	8.00E-10	5.02E-03	1.27E-03	8.75E-03	2.40E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
15	8.50E-02	3.22E-02	1.06E-04	2.59E-09	7.13E-03	1.48E-03	1.24E-02	2.50E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
20	9.34E-02	3.40E-02	1.23E-04	7.20E-09	9.24E-03	1.67E-03	1.63E-02	2.51E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
25	1.02E-01	3.57E-02	1.37E-04	1.63E-08	1.16E-02	1.85E-03	2.04E-02	2.52E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
30	1.10E-01	3.74E-02	1.50E-04	3.33E-08	1.41E-02	2.01E-03	2.50E-02	2.52E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
35	1.20E-01	3.89E-02	1.64E-04	5.91E-08	1.67E-02	2.19E-03	2.95E-02	2.52E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
40	1.30E-01	4.06E-02	1.77E-04	1.01E-07	1.95E-02	2.36E-03	3.52E-02	2.53E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
45	1.39E-01	4.25E-02	1.92E-04	1.71E-07	2.28E-02	2.55E-03	4.23E-02	2.53E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
50	1.50E-01	4.43E-02	2.09E-04	2.61E-07	2.61E-02	2.75E-03	5.06E-02	2.53E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
55	1.62E-01	4.64E-02	2.26E-04	4.18E-07	2.99E-02	2.94E-03	5.95E-02	2.53E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
60	1.77E-01	4.85E-02	2.45E-04	6.20E-07	3.46E-02	3.18E-03	7.12E-02	2.53E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
65	1.96E-01	5.09E-02	2.64E-04	9.08E-07	4.01E-02	3.41E-03	8.41E-02	2.53E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
70	2.16E-01	5.36E-02	2.86E-04	1.42E-06	4.67E-02	3.68E-03	1.01E-01	2.53E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
75	2.42E-01	5.69E-02	3.12E-04	2.22E-06	5.46E-02	4.00E-03	1.24E-01	2.53E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
80	2.76E-01	6.08E-02	3.46E-04	3.33E-06	6.49E-02	4.42E-03	1.56E-01	2.53E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
85	3.26E-01	6.56E-02	3.88E-04	5.35E-06	7.88E-02	5.00E-03	1.95E-01	2.53E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
90	4.08E-01	7.26E-02	4.47E-04	9.08E-06	1.02E-01	5.71E-03	2.72E-01	2.53E-03	5.65E-06	1.73E-07	6.96E-14	2.79E-07	2.19E-08	4.94E-07
95	6.13E-01	8.40E-02	5.55E-04	1.98E-05	1.48E-01	7.07E-03	4.60E-01	2.53E-03	5.01E-04	1.67E-05	4.92E-12	2.14E-05	1.98E-06	5.94E-05
max	5.76E+00	1.18E-01	1.49E-03	5.06E-04	8.32E-01	2.43E-02	5.67E+00	2.54E-03	2.27E+00	1.37E-01	2.90E-07	1.92E-01	8.63E-03	4.64E-01
mean	2.23E-01	4.84E-02	2.47E-04	4.09E-06	4.48E-02	3.22E-03	1.22E-01	2.45E-03	3.74E-03	1.12E-04	1.26E-10	2.19E-04	1.97E-05	7.03E-04
95/50	4.09E+00	1.90E+00	2.65E+00	7.58E+01	5.68E+00	2.57E+00	9.08E+00	1.00E+00	NA	NA	NA	NA	NA	NA
95 - 50	4.63E-01	3.97E-02	3.46E-04	1.95E-05	1.22E-01	4.32E-03	4.09E-01	1.00E-06	5.01E-04	1.67E-05	4.92E-12	2.14E-05	1.98E-06	5.94E-05

Note: Any pathway with a 50th or 95th percentile peak dose that is more than 5 percent of the total peak dose of the same percentile is highlighted. Different colors are used in different rows.

Table B-23 Dominant Pathways for Dose Percentiles 50 Percent and 95 Percent and from Deterministic Analysis by Radionuclide for Resident Farmer Scenario

Radionuclide	Probabilistic Results			Deterministic Results from Table B-10
	Table	50 Percentile	95 Percentile	
C-14	B-11	Plant ingestion, meat ingestion, and milk ingestion (water-independent)	Plant ingestion, meat ingestion, and milk ingestion (water-independent)	Plant ingestion, meat ingestion, and milk ingestion (water-independent)
Co-60	B-12	Direct external exposure	Direct external exposure Plant ingestion (water-independent)	Direct external exposure
Cs-137	B-13	Direct external exposure Plant ingestion, meat ingestion, and milk ingestion (water-independent)	Direct external exposure Plant ingestion, meat ingestion, and milk ingestion (water-independent)	Direct external exposure
H-3	B-14	Milk ingestion, plant ingestion, and meat ingestion (water-independent)	Plant ingestion, Milk ingestion, and meat ingestion (water-independent)	Plant ingestion, milk ingestion, and meat ingestion (water-independent), Inhalation
I-129	B-15	Milk ingestion, plant ingestion, and meat ingestion (water-independent)	Milk ingestion, Plant ingestion, and meat ingestion (water-independent) Water ingestion (water-dependent)	Milk ingestion, plant ingestion, and meat ingestion (water-independent)
Np-237	B-16	Plant ingestion (water-independent) Direct external exposure	Plant ingestion (water-independent) Direct external exposure Water ingestion (water-dependent)	Plant ingestion (water-independent) Direct external exposure
Pu-239	B-17	Plant ingestion and Soil ingestion (water-independent)	Plant ingestion (water-independent)	Plant ingestion and soil ingestion (water-independent) Inhalation
Ra-226	B-18	Plant ingestion (water-independent) Radon-222 inhalation Direct external exposure	Radon-222 inhalation Plant ingestion (water-independent) Direct external exposure	Direct external exposure Radon-222 inhalation Plant ingestion (water-independent)
Ra-228	B-19	Plant ingestion (water-independent) Direct external exposure	Plant ingestion and milk ingestion(water-independent) Direct external exposure	Plant ingestion (water-independent) Direct external exposure
Sr-90	B-20	Plant ingestion and milk ingestion (water-independent)	Plant ingestion and milk ingestion (water-independent)	Plant ingestion and milk ingestion (water-independent)
Tc-99	B-21	Plant ingestion and milk ingestion (water-independent)	Plant ingestion and milk ingestion (water-independent) Water ingestion (water dependent)	Plant ingestion and milk ingestion (water-independent)

Note: For deterministic analysis, any pathway with a peak dose that is more than 5 percent of the peak total dose was considered significant in this analysis. For probabilistic analysis, any pathway with 50th or 95th percentile dose that is more than 5 percent of the 50th or 95th percentile dose, respectively from total dose was considered significant in this analysis. For deterministic analysis, dominant or significant pathways identified are from determininstic run in Table B-10.

Table B-23 Dominant Pathways for Dose Percentiles 50 Percent and 95 Percent and from Deterministic Analysis by Radionuclide for Resident Farmer Scenario (cont.)

Radionuclide	Probabilistic Results			Deterministic Results from Table B-10
	Table	50 Percentile	95 Percentile	
U-238	B-22	Milk ingestion and plant ingestion (water-independent) Direct external exposure	Milk ingestion, and plant ingestion (water-independent) Direct external exposure	Milk ingestion (water-independent) Direct external exposure

Note: For deterministic analysis, any pathway with a peak dose that is more than 5 percent of the peak total dose was considered significant in this analysis. For probabilistic analysis, any pathway with 50^{th} or 95^{th} percentile dose that is more than 5 percent of the 50^{th} or 95^{th} percentile dose, respectively from total dose was considered significant in this analysis. For deterministic analysis, dominant or significant pathways identified are from determininstic run in Table B-10.

Table B-24 Summary of Regression Analysis to Identify Sensitive Parameters Influencing the Peak Total Dose for the Resident Farmer Scenario

C-14 Regression Coefficients for Peak All Pathways			
Repetition =	1	2	3
Coefficient of determination (R-squared) =	0.95	0.95	0.95
Description of probabilistic variable	SRRC	SRRC	SRRC
Thickness of contaminated zone	0.84	0.84	0.83
Area of contaminated zone	0.33	0.34	0.36
Wind speed	-0.28	-0.29	-0.29
Density of contaminated zone	0.16	0.18	0.16
C-14 evasion flux rate from soil	0.05	0.04	0.06
Thickness of evasion layer of C-14 in soil	0.04	0.04	0.05
Co-60 Regression Coefficients for Peak All Pathways			
Repetition =	1	2	3
Coefficient of determination (R-squared) =	0.98	0.98	0.98
Description of probabilistic variable	SRRC	SRRC	SRRC
External gamma shielding factor	0.98	0.98	0.98
Plant transfer factor for Co	0.08	0.08	0.07
Thickness of contaminated zone	0.07	0.07	0.07
Area of contaminated zone	0.03	0.05	0.03
Cs-137 Regression Coefficients for Peak All Pathways			
Repetition =	1	2	3
Coefficient of determination (R-squared) =	0.83	0.84	0.83

Note: For identifying parameters that impact the peak total dose, a cut-off value of 0.05 was subjectively selected for the SRRC.

Table B-24 Summary of Regression Analysis to Identify Sensitive Parameters Influencing the Peak Total Dose for the Resident Farmer Scenario (cont.)

Cs-137 Regression Coefficients for Peak All Pathways (cont.)			
Description of probabilistic variable	SRRC	SRRC	SRRC
Plant transfer factor for Cs	0.58	0.56	0.58
External gamma shielding factor	0.54	0.57	0.54
Thickness of contaminated zone	0.3	0.3	0.29
Depth of roots	-0.2	-0.2	-0.21
Meat transfer factor for Cs	0.18	0.18	0.18
Milk transfer factor for Cs	0.17	0.16	0.16
Livestock fodder intake for milk	0.05	0.02	0.06
Livestock intake of soil	0.04	0.04	0.05
Density of contaminated zone	0.05	0.01	0.06
Area of contaminated zone	0.05	0.04	0.02
H-3 Regression Coefficients for Peak All Pathways			
Repetition =	1	2	3
Coefficient of determination (R-squared) =	0.91	0.92	0.92
Description of probabilistic Variable	SRRC	SRRC	SRRC
Thickness of contaminated zone	0.84	0.84	0.84
Depth of roots	-0.34	-0.34	-0.34
Runoff coefficient	0.15	0.13	0.13
Density of contaminated zone	0.14	0.11	0.14
Precipitation	-0.11	-0.12	-0.12
K_d of H-3 in contaminated zone	-0.09	-0.08	-0.09
Contaminated zone total porosity	-0.07	-0.09	-0.06
Livestock water intake for milk	-0.07	-0.07	-0.08
Contaminated zone hydraulic conductivity	0.06	0.07	0.08
Livestock fodder intake for milk	0.06	0.06	0.08
Contaminated zone b parameter	-0.04	-0.05	-0.03
I-129 Regression Coefficients for Peak All Pathways			
Repetition =	1	2	3
Coefficient of determination (R-squared) =	0.74	0.72	0.73
Description of probabilistic variable	SRRC	SRRC	SRRC
Plant transfer factor for I	0.55	0.53	0.53
Thickness of contaminated zone	0.4	0.4	0.42
Milk transfer factor for I	0.39	0.38	0.38
Depth of roots	-0.21	-0.2	-0.22
Note: For identifying parameters that impact the peak total dose, a cut-off value of 0.05 was subjectively selected for the SRRC.			

Table B-24 Summary of Regression Analysis to Identify Sensitive Parameters Influencing the Peak Total Dose for the Resident Farmer Scenario (cont.)

I-129 Regression Coefficients for Peak All Pathways (cont.)			
Meat transfer factor for I	0.17	0.18	0.17
K_d of I-129 in saturated zone	-0.12	-0.1	-0.13
Saturated zone hydraulic conductivity	0.09	0.1	0.11
Saturated zone hydraulic gradient	0.08	0.09	0.07
Livestock intake of soil	0.06	0.07	0.08
K_d of I-129 in Unsaturated Zone	-0.06	-0.05	-0.07
Np-237 Regression Coefficients for Peak All Pathways			
Repetition =	1	2	3
Coefficient of determination (R-squared) =	0.86	0.86	0.85
Description of probabilistic variable	SRRC	SRRC	SRRC
Plant transfer factor for Np	0.72	0.72	0.71
Thickness of contaminated zone	0.46	0.46	0.47
Depth of roots	-0.3	-0.28	-0.28
External gamma shielding factor	0.18	0.19	0.2
K_d of Np-237 in saturated zone	-0.03	-0.05	-0.03
Saturated zone effective porosity	-0.02	-0.01	-0.06
Pu-239 Regression Coefficients for Peak All Pathways			
Repetition =	1	2	3
Coefficient of determination (R-squared) =	0.88	0.87	0.87
Description of probabilistic variable	SRRC	SRRC	SRRC
Plant transfer factor for Pu	0.73	0.76	0.74
Thickness of contaminated zone	0.48	0.45	0.48
Depth of roots	-0.31	-0.29	-0.3
Meat transfer factor for Pu	0.05	0.04	0.06
Total Porosity of Unsaturated zone	0.05	0.02	0.01
Ra-226 Regression Coefficients for Peak All Pathways			
Repetition =	1	2	3
Coefficient of determination (R-squared) =	0.78	0.78	0.76
Description of probabilistic variable	SRRC	SRRC	SRRC
Building air exchange rate	-0.54	-0.53	-0.53
Thickness of contaminated zone	0.42	0.41	0.41
Plant transfer factor for Ra	0.34	0.33	0.32
Depth of roots	-0.22	-0.22	-0.21
Rn-222 emanation coefficient	0.2	0.21	0.2
Note: For identifying parameters that impact the peak total dose, a cut-off value of 0.05 was subjectively selected for the SRRC.			

Table B-24 Summary of Regression Analysis to Identify Sensitive Parameters Influencing the Peak Total Dose for the Resident Farmer Scenario (cont.)

Ra-226 Regression Coefficients for Peak All Pathways (cont.)			
Plant transfer factor for Pb	0.18	0.19	0.19
Building foundation radon diffusion coefficient	0.13	0.11	0.13
Building room height	-0.11	-0.11	-0.12
External gamma shielding factor	0.11	0.1	0.09
Building foundation total porosity	0.1	0.11	0.09
Building foundation thickness	-0.11	-0.1	-0.09
Density of contaminated zone	0.03	0.07	0.09
Contaminated zone total porosity	-0.09	-0.05	-0.02
Ra-228 Regression Coefficients for Peak All Pathways			
Repetition =	1	2	3
Coefficient of determination (R-squared) =	0.9	0.89	0.9
Description of probabilistic variable	SRRC	SRRC	SRRC
Plant transfer factor for Ra	0.75	0.74	0.77
Thickness of contaminated zone	0.46	0.48	0.47
Depth of roots	-0.3	-0.31	-0.3
External gamma shielding factor	0.11	0.1	0.1
Milk transfer factor for Ra	0.04	0.04	0.06
Effective porosity of unsaturated zone	0.03	0.02	0.05
Sr-90 Regression Coefficients for Peak All Pathways			
Repetition =	1	2	3
Coefficient of determination (R-squared) =	0.91	0.92	0.91
Description of probabilistic variable	SRRC	SRRC	SRRC
Plant transfer factor for Sr	0.8	0.78	0.79
Thickness of contaminated zone	0.44	0.46	0.45
Depth of roots	-0.29	-0.29	-0.29
Milk transfer factor for Sr	0.05	0.06	0.05
Tc-99 Regression Coefficients for Peak All Pathways			
Repetition =	1	2	3
Coefficient of determination (R-squared) =	0.89	0.89	0.89
Description of probabilistic variable	SRRC	SRRC	SRRC
Plant transfer factor for Tc	0.71	0.69	0.7
Thickness of contaminated zone	0.54	0.56	0.55
Depth of roots	-0.28	-0.28	-0.28
K_d of Tc-99 in contaminated zone	0.09	0.08	0.07
Note: For identifying parameters that impact the peak total dose, a cut-off value of 0.05 was subjectively selected for the SRRC.			

Table B-24 Summary of Regression Analysis to Identify Sensitive Parameters Influencing the Peak Total Dose for the Resident Farmer Scenario (cont.)

Tc-99 Regression Coefficients for Peak All Pathways (cont.)			
Milk transfer factor for Tc	0.06	0.07	0.07
Runoff coefficient	0.04	0.04	0.05
U-238 Regression Coefficients for Peak All Pathways			
Repetition =	1	2	3
Coefficient of determination (R-squared) =	0.84	0.84	0.84
Description of probabilistic variable	SRRC	SRRC	SRRC
Milk transfer factor for U	0.74	0.74	0.73
Plant transfer factor for U	0.39	0.4	0.4
Thickness of contaminated zone	0.22	0.23	0.24
External gamma shielding factor	0.18	0.18	0.19
Livestock intake of soil	0.14	0.14	0.16
Depth of roots	-0.15	-0.14	-0.14
Note: For identifying parameters that impact the peak total dose, a cut-off value of 0.05 was subjectively selected for the SRRC.			

B.2 Building Occupancy Scenario

The purpose of this analysis was to illustrate the use of the probabilistic RESRAD-BUILD code to simulate the light industrial use of a decontaminated building as one of the building scenarios described in NUREG/CR-5512 (Kennedy and Strenge 1992) and NUREG-1727. The probabilistic analysis was performed to identify parameters that have significant effect on peak total dose. The probabilistic analysis was also used to illustrate how a data template file of updated input parameters for deterministic analysis may be constructed to transition from the probabilistic dose analysis to a site-specific deterministic analysis.

B.2.1 Selection of Input Parameters for Building Occupancy Scenario

In a probabilistic analysis, behavioral parameters were kept at a fixed value (obtained from DandD) and physical parameters were assigned a statistical distribution. Table B-25 lists parameters required for different pathways in RESRAD-BUILD and DandD codes for the building occupancy scenario.

Table B-26 lists the input parameters of the RESRAD-BUILD code, their base value used in the deterministic calculation, and their statistic distribution (including the distribution function and the associated distribution parameters) used in the probabilistic calculations.

B.2.2 Deterministic Results for Building Occupancy Scenario

Table B-27 presents the deterministic calculation dose results using the base values in Table B-26. The peak total dose for individual radionuclides varied from 1.7E-08 (H-3) to 3.2E-04 mrem/yr per pCi/m^2 (Np-237). Unless all the pathway doses peaked at the same time, the sum of the peak pathway doses will exceed the peak all pathway dose. Any pathway with a peak dose that is more than 5 percent of the peak all pathway dose was considered significant in this analysis and is highlighted in Table B-27. For C-14, ingestion was a dominant exposure pathway. For Co-60, external exposure was a dominant exposure pathway. For Cs-137 and I-129, external exposure and ingestion were dominant exposure pathways. For H-3, Np-237, Pu-239, Sr-90, Tc-99, and U-238, inhalation and ingestion were dominant exposure pathways. For Ra-226, ingestion, external exposure, and radon inhalation were dominant exposure pathways. For Ra-228, radon inhalation, external exposure, inhalation, and ingestion pathways all contributed significantly to the peak total dose. The contamination on different building surfaces contribute differently to peak total dose. Figure B-1 shows the dose contribution of different surfaces to peak total dose.

Table B-25 Parameters Used in RESRAD-BUILD and DandD Codes

Pathway	Common Parameters Used in RESRAD-BUILD and DandD	Parameters Used in RESRAD-BUILD	Parameters Used in DandD
Direct external exposure	Exposure duration Average source activity Dose conversion factors	Source area Shielding parameters (material, thickness, and density) Source location Receptor location	None
Direct ingestion	Exposure duration Source area Average surface source activity Ingestion dose conversion factor	Direct ingestion rate	Effective transfer rate for ingestion
Air Pathways	Occupancy factor Receptor inhalation rate Removable fraction Average surface source activity	Room dimension Air exchange rate Air release fraction Source lifetime Resuspension rate Deposition velocity	Resuspension factor
Inhalation	Inhalation dose conversion factor Receptor inhalation rate	All air pathway parameters	Resuspension factor
Ingestion of deposited materials	NA	All air pathway parameters Indirect ingestion rate Ingestion dose conversion factor	NA
External exposure to deposited materials	NA	All air pathway parameters Shielding parameters Receptor location External dose conversion factor	NA
External exposure due to air submersion	NA	All air pathway parameters Air submersion dose conversion factor	NA
Inhalation of indoor radon progeny	NA	All air pathway parameters Radon release fraction	NA

Table B-26 Base Values and Statistical Distributions of Input Parameters Used in the RESRAD-BUILD Code for the Building Occupancy Scenario Analysis

Input parameter	Units	Type[a]	Base value for deterministic calculation[b]	Probabilistic analysis				Remarks
				Value/ distribution	Distributions statistical parameters[c] 1	2	3	
Case								
Title	–[d]	NA	Building occupancy scenario	NR[e]	NR	NR	NR	The TITLE was used to identify run.
Dose/risk library	–	NA	FGR 11	NR	NR	NR	NR	Dose/risk library contains the dose and risk coefficients used in the calculations. The library selected was FGR 11.
External dose conversion factor	(mrem/yr) per (pCi/g)	M	Nuclide specific	Nuclide specific	NR	NR	NR	Values were from Federal Guidance Report No.12 (FGR-12).
inhalation dose conversion factor	mrem/pCi	M	Nuclide specific	Nuclide specific	NR	NR	NR	Values were from Federal Guidance Report No.11 (FGR-11).
Ingestion dose conversion factor	mrem/pCi	M	Nuclide specific	Nuclide specific	NR	NR	NR	Values were from Federal Guidance Report No.11 (FGR-11).
Air submersion dose conversion factor	(mrem/yr) per (pCi/m^3)	M	Nuclide specific	Nuclide specific	NR	NR	NR	Values were from Federal Guidance Report No.12 (FGR-12).
Time Parameters								
Exposure duration	days	B	365.25	365.25	NR	NR	NR	To match the occupancy period of 365.25 days in NUREG/CR-5512 building occupancy scenario.
Indoor fraction	–	B	0.267	0.267	NR	NR	NR	Base value for deterministic calculation matched the 97.4 d/y time in building in NUREG/CR-5512 building occupancy scenario. This was the time the average member of the screening group spends in the building.
Number of evaluation times	–	P	2	2	NR	NR	NR	RESRAD-BUILD current default. Dose was calculated at the time when the building was released and one year later.
Times for calculations	year	P	1	1	NR	NR	NR	Dose is calculated for one year exposure at the time (t =0 yr) building is released and time (t=1 yr) after building is released.
Maximum number of time integration points	–	P	17	5	NR	NR	NR	The number of points to calculate the time-integrated dose. To reduce the time in probabilistic run less time integration points are used.
Building Parameters								
Number of rooms	–	P	1	1	NR	NR	NR	NUREG/CR-5512 building occupancy scenario assumed only one contaminated room.
Deposition velocity	m/s	P	3.9E-4	Loguniform	2.7E-6	2.7E-3		For deterministic analysis, base value was the mean value from the distribution. For probabilistic analysis, distribution from NUREG/CR-6755 was used.
Resuspension rate	1/s	P, B	6.3E-8	Loguniform	2.5E-11	1.3E-5		For deterministic analysis, base value was the median value from the distribution. For probabilistic analysis, distribution from NUREG/CR-6755 was used.
Room Details								
Room height	m	P	3	3				NUREG/CR-5512, Volume 1
Room area	m^2	P	64	64				NUREG/CR-5512, Volume 1
Air exchange rate for building and room	1/h	B	1.52	1.52	NR	NR	NR	For deterministic analysis, base value was the median value from the distribution from NUREG/CR-6697.

[a] P = physical, B = behavioral, M = metabolic parameter, NA = not applicable.
[b] Base values used in the deterministic run.
[c] Parameter values or distributions used in the probabilistic run.
[d] A dash indicates that the parameter is dimensionless.
[e] NR = parameter not required for the analysis.

Table B-26 Base Values and Statistical Distributions of Input Parameters Used in the RESRAD-BUILD Code for the Building Occupancy Scenario Analysis (cont.)

Input parameter	Units	Type[a]	Base value for deterministic calculation[b]	Probabilistic analysis				Remarks
				Value/ distribution	Distributions statistical parameters[c]			
					1	2	3	
Room Details (cont.)								
Net flow	m^3/h	B	NR	NR	NR	NR	NR	Not required because only one room model was used.
Outdoor inflow	m^3/h	B, P	NR	NR	NR	NR	NR	Outdoor inflow was calculated from room volume and air exchange rate.
Radiological Units								
Activity	pCi	NA	Traditional	Traditional	NR	NR	NR	Traditional units were used.
Dose	mrem	NA	Traditional	Traditional	NR	NR	NR	Traditional units were used.
Receptor Parameters								
Number of receptors	–	B	1	1	NR	NR	NR	Dose was calculated for one receptor.
Receptor room	–	B	1	1	NR	NR	NR	Only one room model was used.
Receptor location	m	B	4,4,1	4,4,1	NR	NR	NR	At 1-m height from the center of the contaminated floor surface.
Receptor time fraction	–	B	1	1	NR	NR	NR	Most conservative value
Receptor inhalation rate	m^3/d	M, B	33.6	33.6	NR	NR	NR	For the building occupancy scenario, base value matched the breathing rate of 1.4 m3/h for the average member of the screening group in NUREG/CR-5512

[a] P = physical, B = behavioral, M = metabolic parameter, NA = not applicable.
[b] Base values used in the deterministic run.
[c] Parameter values or distributions used in the probabilistic run.
[d] A dash indicates that the parameter is dimensionless.
[e] NR = parameter not required for the analysis.

Table B-26 Base Values and Statistical Distributions of Input Parameters Used in the RESRAD-BUILD Code for the Building Occupancy Scenario Analysis (cont.)

Input parameter	Units	Type[a]	Base value for deterministic calculation[b]	Probabilistic analysis				Remarks
				Value/ distribution	Distributions statistical parameters[c]			
					1	2	3	
Receptor Parameters (cont.)								
Receptor indirect ingestion rate	m^2/h	B	1.12E-4	1.12E-4	NR	NR	NR	For deterministic analysis, base value was the mean of the distribution from NUREG/CR-6697
Source 1 Parameters								
Number of sources	none	P	6	6	NR	NR	NR	Floor, ceiling, and four walls of the room were contaminated.
Source 1 type	–	P	Area	Area	NR	NR	NR	Only surface source was considered in building occupancy scenario.
Source 1 room or primary room	–	P	1	1	NR	NR	NR	Only one room was considered.
Source 1 direction	–	P	Z	Z	NR	NR	NR	The direction perpendicular to the exposed area.
Location	m	P	4,4,0	4,4,0	NR	NR	NR	Source center location
Details for Sources 1 & 2								
Geometry	–	NA	Circular	Circular	NR	NR	NR	The circular area would result in higher direct external dose to the receptor.
Area	m^2	P	64	64	NR	NR	NR	Floor and roof were contaminated.

[a] P = physical, B = behavioral, M = metabolic parameter, NA = not applicable.
[b] Base values used in the deterministic run.
[c] Parameter values or distributions used in the probabilistic run.
[d] A dash indicates that the parameter is dimensionless.
[e] NR = parameter not required for the analysis.

Table B-26 Base Values and Statistical Distributions of Input Parameters Used in the RESRAD-BUILD Code for the Building Occupancy Scenario Analysis (cont.)

Input parameter	Units	Type[a]	Base value for deterministic calculation[b]	Probabilistic analysis				Remarks
				Value/ distribution	Distributions statistical parameters[c]			
					1	2	3	
Details for Sources 1 & 2 (cont.)								
Geometry	–	NA	Circular	Circular	NR	NR	NR	The circular area would result in higher direct external dose to the receptor.
Area	m^2	P	64	64	NR	NR	NR	Floor and roof were contaminated.
Air release fraction	–	B	0.357	0.357	NR	NR	NR	For all radionuclides except tritium, base value used (0.357) was equal to the mean value for distribution from NUREG/CR-6697; the value used for tritium (1.0) was the recommended value for gaseous form of tritium.
Direct ingestion rate	1/h	B	4.91E-7	4.91E-7	NR	NR	NR	Base value was calculated from the default ingestion rate of 1.1E-4 m^2/h in NUREG/CR-5512 building occupancy scenario and the total contaminated surface area of 224 m^2 (floor + ceiling + 4 walls). The ingestion rate of 1.1E-4 m^2/h represents the average member of the screening group.

[a] P = physical, B = behavioral, M = metabolic parameter, NA = not applicable.
[b] Base values used in the deterministic run.
[c] Parameter values or distributions used in the probabilistic run.
[d] A dash indicates that the parameter is dimensionless.
[e] NR = parameter not required for the analysis.

Table B-26 Base Values and Statistical Distributions of Input Parameters Used in the RESRAD-BUILD Code for the Building Occupancy Scenario Analysis (cont.)

Input parameter	Units	Type[a]	Base value for deterministic calculation[b]	Probabilistic analysis				Remarks
				Value/ distribution	Distributions statistical parameters[c]			
					1	2	3	
Details for Sources 1 & 2 (cont.)								
Removable fraction	–	P, B	0.1	0.1	NR	NR	NR	10 percent of the contamination was removable (NUREG/CR-5512 building occupancy scenario default). The value matched with Table C7.1 in NUREG-1727.
Time for source removal or source lifetime	days	P, B	10,000	Triangular	1,000	10,000	100,000	Distribution from NUREG/CR-6697. Building with height = 3 m and air exchange rate of 1.5 h^{-1} for a fixed resuspension factor of 1E-6 m gives source life time of about 10,000 days (Table 3.11 in NUREG/CR-6755).
Radon release fraction	–	P, B	0.1	0.1	NR	NR	NR	Radon inhalation pathway was active for radon precursor radionuclide. Base value for deterministic calculation corresponds to the default value used in the RESRAD-BUILD code.
Radionuclide concentration	pCi/m^2	P	1	1	NR	NR	NR	Initial radionuclide concentration
Shielding Parameters for Sources 1, 2, 3, 4, 5, 6 and receptor								
Shielding thickness between source and receptor	cm	P, B	0	0	NR	NR	NR	No shielding was assumed between sources and receptor.

[a] P = physical, B = behavioral, M = metabolic parameter, NA = not applicable.
[b] Base values used in the deterministic run.
[c] Parameter values or distributions used in the probabilistic run.
[d] A dash indicates that the parameter is dimensionless.
[e] NR = parameter not required for the analysis.

Table B-26 Base Values and Statistical Distributions of Input Parameters Used in the RESRAD-BUILD Code for the Building Occupancy Scenario Analysis (cont.)

Input parameter	Units	Type[a]	Base value for deterministic calculation[b]	Probabilistic analysis				Remarks
				Value/ distribution	Distributions statistical parameters[c] 1	2	3	
Shielding Parameters for Sources 1, 2, 3, 4, 5, 6 and receptor (cont.)								
Shielding density between source and receptor	g/cm^3	P	NR	NR	NR	NR	NR	No shielding was assumed between sources and receptor.
Shielding material between source and receptor	–	P	NR	NR	NR	NR	NR	No shielding was assumed between sources and receptor.
Source 2 Parameters								
Type	–	P	Area	Area	NR	NR	NR	Only surface source was considered in building occupancy scenario.
Room	–	P	1	1	NR	NR	NR	Only one room was considered.
Direction	–	P	Z	Z	NR	NR	NR	The direction perpendicular to the exposed area.
Location	m	P	4,4,3	4,4,3	NR	NR	NR	Source center location
Source 3 Parameters								
Type	–	P	Area	Area	NR	NR	NR	Only surface source was considered in building occupancy scenario.
Room	–	P	1	1	NR	NR	NR	Only one room was considered.
Direction	–	P	X	X	NR	NR	NR	The direction perpendicular to the exposed area.
Location	M	P	0,4,1.5	0,4,1.5	NR	NR	NR	Source center location
Details for Source 3, 4, 5, 6 Detail parameters for sources 4, 5, and 6 were the same as for source 3.								
Geometry	–	NA	Circular	Circular	NR	NR	NR	The circular area would result in higher direct external dose to the receptor.
Area	m^2	P	24	24	NR	NR	NR	Wall area

[a] P = physical, B = behavioral, M = metabolic parameter, NA = not applicable.
[b] Base values used in the deterministic run.
[c] Parameter values or distributions used in the probabilistic run.
[d] A dash indicates that the parameter is dimensionless.
[e] NR = parameter not required for the analysis.

Table B-26 Base Values and Statistical Distributions of Input Parameters Used in the RESRAD-BUILD Code for the Building Occupancy Scenario Analysis (cont.)

Input parameter	Units	Type[a]	Base value for deterministic calculation[b]	Probabilistic analysis: Value/ distribution	Distributions statistical parameters[c]: 1	2	3	Remarks
Details for Source 3, 4, 5, 6 (cont.) Detail parameters for sources 4, 5, and 6 were the same as for source 3.								
Geometry	–	NA	Circular	Circular	NR	NR	NR	The circular area would result in higher direct external dose to the receptor.
Area	m^2	P	24	24	NR	NR	NR	Wall area
Air release fraction	–	B	0.357	0.357	NR	NR	NR	For all radionuclides except tritium, value used (0.357) was equal to the mean value for distribution from NUREG/CR-6697 and the value used for tritium (1.0), was the recommended value for gaseous form of tritium.
Direct ingestion rate	1/h	B	4.91E-7	4.91E-7	NR	NR	NR	Calculated from the default ingestion rate of 1.1E-4 m^2/h in NUREG/CR-5512 building occupancy scenario and the total contaminated surface area of 224 m^2. The ingestion rate of 1.1E-4 m^2/h represents the average member of the screening group.
Time for source removal or source lifetime	days	P, B	10,000	Triangular	1000	10,000	100,000	Distribution from NUREG/CR-6697

[a] P = physical, B = behavioral, M = metabolic parameter, NA = not applicable.
[b] Base values used in the deterministic run.
[c] Parameter values or distributions used in the probabilistic run.
[d] A dash indicates that the parameter is dimensionless.
[e] NR = parameter not required for the analysis.

Table B-26 Base Values and Statistical Distributions of Input Parameters Used in the RESRAD-BUILD Code for the Building Occupancy Scenario Analysis (cont.)

Input parameter	Units	Type[a]	Base value for deterministic calculation[b]	Probabilistic analysis: Value/ distribution	Distributions statistical parameters[c]: 1	2	3	Remarks
Details for Source 3, 4, 5, 6 (cont.) Detail parameters for sources 4, 5, and 6 were the same as for source 3.								
Radon release fraction	–	P, B	0.1	0.1	NR	NR	NR	Radon inhalation pathway was active for radon precursor radionuclide. Base value for deterministic calculation corresponds to the default value used in the RESRAD-BUILD code.
Radionuclide concentration	pCi/m^2	P	1	1	NR	NR	NR	Initial radionuclide concentration
Source 4 Parameters								
Type	–	P	Area	Area	NR	NR	NR	Only surface source was considered in building occupancy scenario.
Room	–	P	1	1	NR	NR	NR	Only one room was considered.
Direction	–	P	X	X	NR	NR	NR	The direction perpendicular to the exposed area.
Location	m	P	8,4,1.5	8,4,1.5	NR	NR	NR	Source center location
Source 5 Parameters								
Type	–	P	Area	Area	NR	NR	NR	Only surface source was considered in building occupancy scenario.
Room	–	P	1	1	NR	NR	NR	Only one room was considered.
Direction	–	P	Y	Y	NR	NR	NR	The direction perpendicular to the exposed area.
Location	m	P	4,0,1.5	4,0,1.5	NR	NR	NR	Source center location.

[a] P = physical, B = behavioral, M = metabolic parameter, NA = not applicable.
[b] Base values used in the deterministic run.
[c] Parameter values or distributions used in the probabilistic run.
[d] A dash indicates that the parameter is dimensionless.
[e] NR = parameter not required for the analysis.

Table B-26 Base Values and Statistical Distributions of Input Parameters Used in the RESRAD-BUILD Code for the Building Occupancy Scenario Analysis (cont.)

Input parameter	Units	Type[a]	Base value for deterministic calculation[b]	Probabilistic analysis				Remarks
				Value/ distribution	Distributions statistical parameters[c]			
					1	2	3	
Source 6 Parameters								
Type	–	P	Area	Area	NR	NR	NR	Only surface source was considered in the building occupancy scenario.
Room	–	P	1	1	NR	NR	NR	Only one room was considered.
Direction	–	P	Y	Y	NR	NR	NR	The direction perpendicular to the exposed area.
Location	m	P	4,8,1.5	4,8,1.5	NR	NR	NR	Source center location

[a] P = physical, B = behavioral, M = metabolic parameter, NA = not applicable.
[b] Base values used in the deterministic run.
[c] Parameter values or distributions used in the probabilistic run.
[d] A dash indicates that the parameter is dimensionless.
[e] NR = parameter not required for the analysis.

Table B-27 Peak Total Dose and Dose Contributions from Individual Pathways Obtained with Deterministic Calculations for the Building Occupancy Scenario Concerning Building Surface Contamination by Each Radionuclide Selected for Evaluation (mrem/yr per pCi/m^2)

Radionuclides	Total	External	External Exposure from Deposition	Immersion	Inhalation	Radon	Ingestion
C-14	5.43E-08	2.90E-10	9.52E-14	7.98E-16	7.81E-10	0.00E+00	5.32E-08
Co-60	4.16E-05	4.09E-05	1.27E-08	4.13E-10	7.53E-08	0.00E+00	6.41E-07
Cs-137	1.14E-05	1.01E-05	3.36E-09	9.58E-11	1.18E-08	0.00E+00	1.26E-06
H-3	1.70E-08	0.00E+00	0.00E+00	3.19E-14	9.70E-10	0.00E+00	1.60E-08
I-129	7.78E-06	6.79E-07	1.30E-10	1.35E-12	6.51E-08	0.00E+00	7.03E-06
Np-237	3.19E-04	4.06E-06	1.37E-09	3.70E-11	2.02E-04	0.00E+00	1.13E-04
Pu-239	2.25E-04	1.52E-08	6.82E-12	1.51E-14	1.61E-04	0.00E+00	6.43E-05
Ra-226	8.02E-05	3.06E-05	1.03E-08	3.16E-10	3.31E-06	1.02E-05	3.60E-05
Ra-228	1.50E-04	2.03E-05	6.16E-09	2.00E-10	2.09E-05	7.14E-05	3.78E-05
Sr-90	4.43E-06	1.03E-07	3.42E-11	6.93E-13	4.82E-07	0.00E+00	3.85E-06
Tc-99	4.14E-08	1.18E-09	3.92E-13	5.78E-15	3.11E-09	0.00E+00	3.71E-08
U-238	5.15E-05	5.56E-07	1.89E-10	4.87E-12	4.41E-05	4.69E-21	6.83E-06

Note: Any pathway with a peak dose that is more than 5 percent of the peak total dose is highlighted.

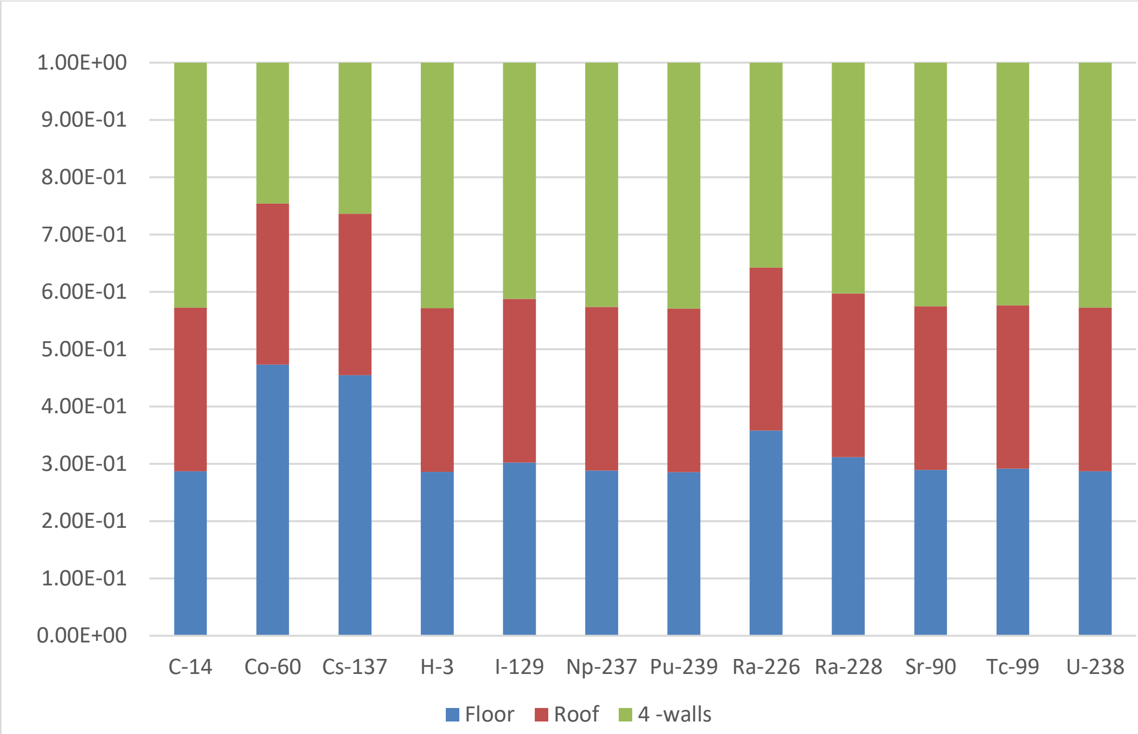

Figure B-1 Fractional Contribution of Different Surfaces to Total Dose in Building Occupancy Scenario

B.2.3 Probabilistic Results for Building Occupancy Scenario

For each probabilistic analysis, input data sets were generated with the specifications of 1000 observation, 3 repetitions, and LHS sampling technique. After the probabilistic calculations were completed, the dose results obtained with all the input data sets were analyzed by the RESRAD-BUILD code, and the average, minimum, maximum, and percentiles of the peak total dose and the peak pathway doses were reported. Tables B-28 through B-39 list the reported results for the building occupancy scenario concerning building surface contamination by each of the 12 radionuclides selected for evaluation. Two variability criteria were used to analyze the results: ratio of peak dose at the 95 to 50 percentile and difference of peak dose at 95 percentile to peak dose at 50 percentile are used. The ratio gives relative variability and the difference gives the absolute variability. The ratio and difference are in the last two rows of the dose distribution tables.

The dominant exposure pathways in this analysis are identified by comparing the peak pathway dose at two percentiles (50 and 95) to the peak total dose at the same percentiles. The dominant exposure pathways at 50 percent and 95 percent are highlighted in Tables B-28 through B-39. Table B-40 presents the dominant exposure pathways identified for 50 and 95 dose percentiles by radionuclides and compares it with dominant exposure pathways identified from deterministic analysis.

B.2.4 Regression Analysis for Building Occupancy Scenario

The next step in the process was to identify parameters that are highly correlated with dose. Table B-41 summarizes the regression analysis results for the building occupancy scenario and lists SRRC values for all parameters used in the analysis. The influence of a parameter is categorized subjectively in to three groups: SRRC >0.4 (high influence on dose), SRRC in the range ≥0.2 to 0.4 (medium influence on dose), and SRRC in the range ≥0.1 to <0.2 (low influence on dose). For identifying parameters that impact the peak total dose, a cut-off value of 0.1 was subjectively selected for the SRRC, judging by the range of SRRC from all input parameters. The SRRC cutoff values and its range for categorizing input parameters are not absolute, they depend on the regression analysis results of each run and should be judged by the analyst.

The parameters that impact the peak total dose for each radionuclide as listed in Table B-41 match with the dominant exposure pathways identified in Tables B-28 through B-39.

Table B-28 Distributions of Peak Total Dose and Peak Pathway Dose Obtained with Probabilistic Calculations for the Building Occupancy Scenario Concerning Building Surface Contamination by C-14 (mrem/yr per pCi/m²)

Percentile	Total	External	Inhalation	External Exposure from Deposition	Immersion	Ingestion	Radon
5	5.40E-08	2.90E-10	1.75E-10	2.32E-17	1.79E-16	5.31E-08	0.00E+00
10	5.40E-08	2.90E-10	1.96E-10	8.24E-17	2.00E-16	5.32E-08	0.00E+00
15	5.40E-08	2.90E-10	2.12E-10	1.91E-16	2.17E-16	5.33E-08	0.00E+00
20	5.40E-08	2.90E-10	2.30E-10	4.68E-16	2.35E-16	5.34E-08	0.00E+00
25	5.40E-08	2.90E-10	2.46E-10	1.09E-15	2.51E-16	5.34E-08	0.00E+00
30	5.40E-08	2.90E-10	2.62E-10	2.32E-15	2.68E-16	5.35E-08	0.00E+00
35	5.40E-08	2.90E-10	2.77E-10	4.33E-15	2.83E-16	5.35E-08	0.00E+00
40	5.41E-08	2.90E-10	2.90E-10	8.23E-15	2.97E-16	5.35E-08	0.00E+00
45	5.41E-08	2.90E-10	3.04E-10	1.82E-14	3.11E-16	5.36E-08	0.00E+00
50	5.41E-08	2.90E-10	3.22E-10	3.62E-14	3.29E-16	5.36E-08	0.00E+00
55	5.43E-08	2.90E-10	3.43E-10	6.91E-14	3.50E-16	5.37E-08	0.00E+00
60	5.45E-08	2.90E-10	3.62E-10	1.32E-13	3.70E-16	5.39E-08	0.00E+00
65	5.51E-08	2.90E-10	3.80E-10	2.61E-13	3.88E-16	5.44E-08	0.00E+00
70	5.59E-08	2.90E-10	4.04E-10	4.68E-13	4.12E-16	5.53E-08	0.00E+00
75	5.72E-08	2.90E-10	4.32E-10	7.98E-13	4.41E-16	5.66E-08	0.00E+00
80	6.07E-08	2.90E-10	4.63E-10	1.63E-12	4.73E-16	6.00E-08	0.00E+00
85	6.98E-08	2.90E-10	5.10E-10	3.89E-12	5.21E-16	6.90E-08	0.00E+00
90	9.32E-08	2.90E-10	5.66E-10	9.63E-12	5.78E-16	9.26E-08	0.00E+00
95	1.73E-07	2.90E-10	6.83E-10	2.93E-11	6.98E-16	1.72E-07	0.00E+00
Mean	8.07E-08	2.90E-10	3.63E-10	6.58E-12	3.71E-16	8.01E-08	0.00E+00
Max.	1.95E-06	2.91E-10	1.83E-09	4.66E-10	1.87E-15	1.95E-06	0.00E+00
95/50	3.19E+00	1.00E+00	2.12E+00	8.10E+02	2.12E+00	3.21E+00	NA
95-50	1.19E-07	1.00E-13	3.61E-10	2.92E-11	3.69E-16	1.19E-07	0.00E+00

Note: Any pathway with a 50th or 95th percentile peak dose that is more than 5 percent of the total peak dose of the same percentile is highlighted. Different colors are used in different rows.

Table B-29 Distributions of Peak Total Dose and Peak Pathway Dose Obtained with Probabilistic Calculations for the Building Occupancy Scenario Concerning Building Surface Contamination by Co-60 (mrem/yr per pCi/m^2)

Percentile	Total	External	Inhalation	External Exposure from Deposition	Immersion	Ingestion	Radon
5	4.16E-05	4.09E-05	1.47E-08	3.35E-12	8.07E-11	6.40E-07	0.00E+00
10	4.16E-05	4.09E-05	1.71E-08	1.19E-11	9.38E-11	6.42E-07	0.00E+00
15	4.16E-05	4.09E-05	1.89E-08	2.73E-11	1.04E-10	6.43E-07	0.00E+00
20	4.16E-05	4.09E-05	2.02E-08	6.55E-11	1.11E-10	6.43E-07	0.00E+00
25	4.16E-05	4.09E-05	2.18E-08	1.55E-10	1.19E-10	6.44E-07	0.00E+00
30	4.16E-05	4.09E-05	2.33E-08	3.05E-10	1.28E-10	6.44E-07	0.00E+00
35	4.16E-05	4.09E-05	2.50E-08	4.95E-10	1.37E-10	6.45E-07	0.00E+00
40	4.16E-05	4.09E-05	2.64E-08	7.83E-10	1.45E-10	6.45E-07	0.00E+00
45	4.16E-05	4.09E-05	2.79E-08	1.19E-09	1.53E-10	6.45E-07	0.00E+00
50	4.16E-05	4.09E-05	2.94E-08	1.86E-09	1.61E-10	6.46E-07	0.00E+00
55	4.16E-05	4.09E-05	3.13E-08	2.89E-09	1.71E-10	6.46E-07	0.00E+00
60	4.16E-05	4.09E-05	3.30E-08	4.60E-09	1.81E-10	6.46E-07	0.00E+00
65	4.16E-05	4.09E-05	3.52E-08	7.62E-09	1.93E-10	6.47E-07	0.00E+00
70	4.16E-05	4.09E-05	3.73E-08	1.16E-08	2.04E-10	6.48E-07	0.00E+00
75	4.16E-05	4.09E-05	3.98E-08	1.85E-08	2.18E-10	6.50E-07	0.00E+00
80	4.16E-05	4.09E-05	4.29E-08	2.93E-08	2.35E-10	6.54E-07	0.00E+00
85	4.17E-05	4.09E-05	4.74E-08	4.58E-08	2.60E-10	6.59E-07	0.00E+00
90	4.17E-05	4.09E-05	5.31E-08	7.37E-08	2.91E-10	6.68E-07	0.00E+00
95	4.17E-05	4.09E-05	6.51E-08	1.25E-07	3.57E-10	6.85E-07	0.00E+00
Mean	4.16E-05	4.09E-05	3.32E-08	2.18E-08	1.82E-10	6.51E-07	0.00E+00
Max.	4.20E-05	4.09E-05	1.80E-07	3.57E-07	9.87E-10	7.60E-07	0.00E+00
95/50	1.00E+00	1.00E+00	2.21E+00	6.71E+01	2.21E+00	1.06E+00	NA
95-50	1.40E-07	1.00E-08	3.57E-08	1.23E-07	1.96E-10	3.97E-08	0.00E+00

Note: Any pathway with a 50th or 95th percentile peak dose that is more than 5 percent of the total peak dose of the same percentile is highlighted. Different colors are used in different rows.

Table B-30 Distributions of Peak Total Dose and Peak Pathway Dose Obtained with Probabilistic Calculations for the Building Occupancy Scenario Concerning Building Surface Contamination by Cs-137 (mrem/yr per pCi/m^2)

Percentile	Total	External	Inhalation	External Exposure from Deposition	Immersion	Ingestion	Radon
5	1.14E-05	1.01E-05	2.37E-09	8.31E-13	1.93E-11	1.26E-06	0.00E+00
10	1.14E-05	1.01E-05	2.76E-09	2.95E-12	2.25E-11	1.26E-06	0.00E+00
15	1.14E-05	1.01E-05	3.00E-09	6.83E-12	2.44E-11	1.26E-06	0.00E+00
20	1.14E-05	1.01E-05	3.22E-09	1.66E-11	2.62E-11	1.26E-06	0.00E+00
25	1.14E-05	1.01E-05	3.48E-09	3.90E-11	2.83E-11	1.26E-06	0.00E+00
30	1.14E-05	1.01E-05	3.70E-09	8.16E-11	3.01E-11	1.26E-06	0.00E+00
35	1.14E-05	1.01E-05	3.94E-09	1.48E-10	3.21E-11	1.27E-06	0.00E+00
40	1.14E-05	1.01E-05	4.17E-09	2.83E-10	3.40E-11	1.27E-06	0.00E+00
45	1.14E-05	1.01E-05	4.38E-09	5.50E-10	3.56E-11	1.27E-06	0.00E+00
50	1.14E-05	1.01E-05	4.60E-09	9.35E-10	3.74E-11	1.27E-06	0.00E+00
55	1.14E-05	1.01E-05	4.89E-09	1.57E-09	3.98E-11	1.27E-06	0.00E+00
60	1.14E-05	1.01E-05	5.22E-09	2.47E-09	4.25E-11	1.27E-06	0.00E+00
65	1.14E-05	1.01E-05	5.52E-09	4.12E-09	4.49E-11	1.27E-06	0.00E+00
70	1.14E-05	1.01E-05	5.83E-09	6.89E-09	4.75E-11	1.28E-06	0.00E+00
75	1.15E-05	1.01E-05	6.25E-09	1.17E-08	5.09E-11	1.29E-06	0.00E+00
80	1.15E-05	1.01E-05	6.75E-09	1.89E-08	5.49E-11	1.31E-06	0.00E+00
85	1.15E-05	1.01E-05	7.45E-09	3.60E-08	6.07E-11	1.36E-06	0.00E+00
90	1.17E-05	1.01E-05	8.32E-09	6.75E-08	6.77E-11	1.44E-06	0.00E+00
95	1.19E-05	1.01E-05	1.01E-08	1.31E-07	8.18E-11	1.61E-06	0.00E+00
Mean	1.15E-05	1.01E-05	5.23E-09	2.09E-08	4.26E-11	1.32E-06	0.00E+00
Max.	1.31E-05	1.01E-05	2.77E-08	4.62E-07	2.25E-10	2.49E-06	0.00E+00
95/50	1.04E+00	1.00E+00	2.18E+00	1.40E+02	2.19E+00	1.27E+00	NA
95-50	4.70E-07	0.00E+00	5.45E-09	1.30E-07	4.44E-11	3.45E-07	0.00E+00

Note: Any pathway with a 50^{th} or 95^{th} percentile peak dose that is more than 5 percent of the total peak dose of the same percentile is highlighted. Different colors are used in different rows.

Table B-31 Distributions of Peak Total Dose and Peak Pathway Dose Obtained with Probabilistic Calculations for the Building Occupancy Scenario Concerning Building Surface Contamination by H-3 (mrem/yr per pCi/m^2)

Percentile	Total	External	Inhalation	External Exposure from Deposition	Immersion	Ingestion	Radon
5	1.62E-08	0.00E+00	1.92E-10	0.00E+00	6.32E-15	1.58E-08	0.00E+00
10	1.62E-08	0.00E+00	2.22E-10	0.00E+00	7.29E-15	1.59E-08	0.00E+00
15	1.63E-08	0.00E+00	2.45E-10	0.00E+00	8.04E-15	1.59E-08	0.00E+00
20	1.63E-08	0.00E+00	2.63E-10	0.00E+00	8.64E-15	1.59E-08	0.00E+00
25	1.63E-08	0.00E+00	2.83E-10	0.00E+00	9.30E-15	1.59E-08	0.00E+00
30	1.63E-08	0.00E+00	3.00E-10	0.00E+00	9.86E-15	1.59E-08	0.00E+00
35	1.64E-08	0.00E+00	3.22E-10	0.00E+00	1.06E-14	1.59E-08	0.00E+00
40	1.64E-08	0.00E+00	3.42E-10	0.00E+00	1.12E-14	1.60E-08	0.00E+00
45	1.64E-08	0.00E+00	3.59E-10	0.00E+00	1.18E-14	1.60E-08	0.00E+00
50	1.65E-08	0.00E+00	3.78E-10	0.00E+00	1.24E-14	1.60E-08	0.00E+00
55	1.65E-08	0.00E+00	4.01E-10	0.00E+00	1.32E-14	1.60E-08	0.00E+00
60	1.66E-08	0.00E+00	4.27E-10	0.00E+00	1.40E-14	1.61E-08	0.00E+00
65	1.67E-08	0.00E+00	4.52E-10	0.00E+00	1.49E-14	1.62E-08	0.00E+00
70	1.68E-08	0.00E+00	4.80E-10	0.00E+00	1.58E-14	1.63E-08	0.00E+00
75	1.71E-08	0.00E+00	5.12E-10	0.00E+00	1.68E-14	1.66E-08	0.00E+00
80	1.75E-08	0.00E+00	5.53E-10	0.00E+00	1.82E-14	1.70E-08	0.00E+00
85	1.82E-08	0.00E+00	6.10E-10	0.00E+00	2.00E-14	1.78E-08	0.00E+00
90	1.97E-08	0.00E+00	6.82E-10	0.00E+00	2.24E-14	1.93E-08	0.00E+00
95	2.24E-08	0.00E+00	8.34E-10	0.00E+00	2.74E-14	2.21E-08	0.00E+00
Mean	1.73E-08	0.00E+00	4.29E-10	0.00E+00	1.41E-14	1.69E-08	0.00E+00
Max.	3.48E-08	0.00E+00	2.29E-09	0.00E+00	7.54E-14	3.44E-08	0.00E+00
95/50	1.36E+00	NA	2.20E+00	NA	2.20E+00	1.38E+00	NA
95-50	5.94E-09	0.00E+00	4.55E-10	0.00E+00	1.50E-14	6.10E-09	0.00E+00

Note: Any pathway with a 50th or 95th percentile peak dose that is more than 5 percent of the total peak dose of the same percentile is highlighted. Different colors are used in different rows.

Table B-32 Distributions of Peak Total Dose and Peak Pathway Dose Obtained with Probabilistic Calculations for the Building Occupancy Scenario Concerning Building Surface Contamination by I-129 (mrem/yr per pCi/m^2)

Percentile	Total	External	Inhalation	External Exposure from Deposition	Immersion	Ingestion	Radon
5	7.74E-06	6.79E-07	1.47E-08	5.52E-14	3.05E-13	7.01E-06	0.00E+00
10	7.75E-06	6.80E-07	1.63E-08	1.96E-13	3.40E-13	7.03E-06	0.00E+00
15	7.75E-06	6.80E-07	1.77E-08	4.54E-13	3.68E-13	7.04E-06	0.00E+00
20	7.76E-06	6.80E-07	1.91E-08	1.11E-12	3.98E-13	7.05E-06	0.00E+00
25	7.76E-06	6.80E-07	2.06E-08	2.59E-12	4.28E-13	7.05E-06	0.00E+00
30	7.76E-06	6.80E-07	2.18E-08	5.51E-12	4.55E-13	7.06E-06	0.00E+00
35	7.77E-06	6.80E-07	2.31E-08	1.03E-11	4.81E-13	7.06E-06	0.00E+00
40	7.77E-06	6.80E-07	2.42E-08	1.96E-11	5.04E-13	7.07E-06	0.00E+00
45	7.77E-06	6.80E-07	2.54E-08	4.33E-11	5.29E-13	7.07E-06	0.00E+00
50	7.78E-06	6.80E-07	2.68E-08	8.60E-11	5.59E-13	7.08E-06	0.00E+00
55	7.80E-06	6.80E-07	2.86E-08	1.64E-10	5.96E-13	7.09E-06	0.00E+00
60	7.83E-06	6.80E-07	3.02E-08	3.19E-10	6.30E-13	7.12E-06	0.00E+00
65	7.90E-06	6.80E-07	3.17E-08	6.27E-10	6.60E-13	7.19E-06	0.00E+00
70	8.01E-06	6.80E-07	3.37E-08	1.13E-09	7.01E-13	7.31E-06	0.00E+00
75	8.19E-06	6.80E-07	3.61E-08	1.93E-09	7.51E-13	7.49E-06	0.00E+00
80	8.66E-06	6.80E-07	3.87E-08	4.02E-09	8.06E-13	7.94E-06	0.00E+00
85	9.90E-06	6.80E-07	4.25E-08	9.53E-09	8.86E-13	9.17E-06	0.00E+00
90	1.31E-05	6.80E-07	4.73E-08	2.35E-08	9.84E-13	1.24E-05	0.00E+00
95	2.45E-05	6.80E-07	5.71E-08	7.38E-08	1.19E-12	2.37E-05	0.00E+00
Mean	1.18E-05	6.80E-07	3.03E-08	1.79E-08	6.31E-13	1.11E-05	0.00E+00
Max.	3.27E-04	6.80E-07	1.53E-07	1.41E-06	3.18E-12	3.25E-04	0.00E+00
95/50	3.15E+00	1.00E+00	2.13E+00	8.58E+02	2.13E+00	3.35E+00	NA
95-50	1.67E-05	2.00E-10	3.02E-08	7.37E-08	6.30E-13	1.66E-05	0.00E+00

Note: Any pathway with a 50th or 95th percentile peak dose that is more than 5 percent of the total peak dose of the same percentile is highlighted. Different colors are used in different rows.

Table B-33 Distributions of Peak Total Dose and Peak Pathway Dose Obtained with Probabilistic Calculations for the Building Occupancy Scenario Concerning Building Surface Contamination by Np-237 (mrem/yr per pCi/m²)

Percentile	Total	External	Inhalation	External Exposure from Deposition	Immersion	Ingestion	Radon
5	1.66E-04	4.06E-06	4.55E-05	3.34E-13	8.33E-12	1.13E-04	0.00E+00
10	1.71E-04	4.06E-06	5.06E-05	1.19E-12	9.27E-12	1.13E-04	0.00E+00
15	1.76E-04	4.06E-06	5.49E-05	2.75E-12	1.01E-11	1.13E-04	0.00E+00
20	1.82E-04	4.06E-06	5.94E-05	6.73E-12	1.09E-11	1.14E-04	0.00E+00
25	1.87E-04	4.07E-06	6.38E-05	1.57E-11	1.17E-11	1.14E-04	0.00E+00
30	1.92E-04	4.07E-06	6.78E-05	3.34E-11	1.24E-11	1.14E-04	0.00E+00
35	1.96E-04	4.07E-06	7.17E-05	6.23E-11	1.31E-11	1.14E-04	0.00E+00
40	2.01E-04	4.07E-06	7.52E-05	1.19E-10	1.38E-11	1.14E-04	0.00E+00
45	2.06E-04	4.07E-06	7.88E-05	2.63E-10	1.44E-11	1.14E-04	0.00E+00
50	2.12E-04	4.07E-06	8.33E-05	5.21E-10	1.53E-11	1.14E-04	0.00E+00
55	2.17E-04	4.07E-06	8.88E-05	9.96E-10	1.63E-11	1.14E-04	0.00E+00
60	2.24E-04	4.07E-06	9.38E-05	1.93E-09	1.72E-11	1.15E-04	0.00E+00
65	2.32E-04	4.07E-06	9.84E-05	3.80E-09	1.80E-11	1.16E-04	0.00E+00
70	2.40E-04	4.07E-06	1.05E-04	6.83E-09	1.91E-11	1.18E-04	0.00E+00
75	2.54E-04	4.07E-06	1.12E-04	1.17E-08	2.05E-11	1.21E-04	0.00E+00
80	2.68E-04	4.07E-06	1.20E-04	2.44E-08	2.20E-11	1.28E-04	0.00E+00
85	2.96E-04	4.07E-06	1.32E-04	5.77E-08	2.42E-11	1.48E-04	0.00E+00
90	3.49E-04	4.07E-06	1.47E-04	1.42E-07	2.69E-11	1.99E-04	0.00E+00
95	4.88E-04	4.07E-06	1.77E-04	4.47E-07	3.24E-11	3.82E-04	0.00E+00
Mean	2.76E-04	4.07E-06	9.40E-05	1.08E-07	1.72E-11	1.78E-04	0.00E+00
Max.	5.37E-03	4.07E-06	4.74E-04	8.52E-06	8.67E-11	5.22E-03	0.00E+00
95/50	2.31E+00	1.00E+00	2.13E+00	8.58E+02	2.13E+00	3.35E+00	NA
95-50	2.76E-04	1.00E-09	9.38E-05	4.46E-07	1.72E-11	2.68E-04	0.00E+00

Note: Any pathway with a 50th or 95th percentile peak dose that is more than 5 percent of the total peak dose of the same percentile is highlighted. Different colors are used in different rows.

Table B-34 Distributions of Peak Total Dose and Peak Pathway Dose Obtained with Probabilistic Calculations for the Building Occupancy Scenario Concerning Building Surface Contamination by Pu-239 (mrem/yr per pCi/m^2)

Percentile	Total	External	Inhalation	External Exposure from Deposition	Immersion	Ingestion	Radon
5	1.29E-04	1.52E-08	3.61E-05	1.66E-15	3.40E-15	9.00E-05	0.00E+00
10	1.33E-04	1.52E-08	4.02E-05	5.90E-15	3.79E-15	9.02E-05	0.00E+00
15	1.37E-04	1.52E-08	4.36E-05	1.37E-14	4.11E-15	9.03E-05	0.00E+00
20	1.42E-04	1.52E-08	4.72E-05	3.35E-14	4.45E-15	9.04E-05	0.00E+00
25	1.45E-04	1.52E-08	5.06E-05	7.81E-14	4.77E-15	9.05E-05	0.00E+00
30	1.49E-04	1.52E-08	5.38E-05	1.66E-13	5.07E-15	9.05E-05	0.00E+00
35	1.53E-04	1.52E-08	5.69E-05	3.10E-13	5.36E-15	9.06E-05	0.00E+00
40	1.56E-04	1.52E-08	5.97E-05	5.89E-13	5.63E-15	9.07E-05	0.00E+00
45	1.61E-04	1.52E-08	6.26E-05	1.30E-12	5.90E-15	9.07E-05	0.00E+00
50	1.65E-04	1.52E-08	6.61E-05	2.59E-12	6.23E-15	9.08E-05	0.00E+00
55	1.70E-04	1.52E-08	7.05E-05	4.95E-12	6.65E-15	9.09E-05	0.00E+00
60	1.75E-04	1.52E-08	7.45E-05	9.61E-12	7.02E-15	9.13E-05	0.00E+00
65	1.81E-04	1.52E-08	7.81E-05	1.88E-11	7.36E-15	9.22E-05	0.00E+00
70	1.88E-04	1.52E-08	8.30E-05	3.39E-11	7.82E-15	9.37E-05	0.00E+00
75	1.99E-04	1.52E-08	8.89E-05	5.81E-11	8.38E-15	9.60E-05	0.00E+00
80	2.10E-04	1.52E-08	9.53E-05	1.20E-10	8.98E-15	1.02E-04	0.00E+00
85	2.32E-04	1.52E-08	1.05E-04	2.82E-10	9.87E-15	1.18E-04	0.00E+00
90	2.74E-04	1.52E-08	1.17E-04	7.02E-10	1.10E-14	1.58E-04	0.00E+00
95	3.80E-04	1.52E-08	1.41E-04	2.20E-09	1.33E-14	3.02E-04	0.00E+00
Mean	2.15E-04	1.52E-08	7.46E-05	5.20E-10	7.03E-15	1.40E-04	0.00E+00
Max.	4.02E-03	1.52E-08	3.76E-04	3.98E-08	3.55E-14	3.92E-03	0.00E+00
95/50	2.30E+00	1.00E+00	2.13E+00	8.50E+02	2.13E+00	3.33E+00	NA
95-50	2.15E-04	0.00E+00	7.45E-05	2.20E-09	7.02E-15	2.11E-04	0.00E+00

Note: Any pathway with a 50th or 95th percentile peak dose that is more than 5 percent of the total peak dose of the same percentile is highlighted. Different colors are used in different rows.

Table B-35 Distributions of Peak Total Dose and Peak Pathway Dose Obtained with Probabilistic Calculations for the Building Occupancy Scenario Concerning Building Surface Contamination by Ra-226 (mrem/yr per pCi/m^2)

Percentile	Total	External	Inhalation	External Exposure from Deposition	Immersion	Ingestion	Radon
5	7.58E-05	3.06E-05	7.29E-07	2.51E-12	7.01E-11	3.57E-05	6.73E-06
10	7.73E-05	3.07E-05	8.20E-07	8.92E-12	7.87E-11	3.57E-05	7.67E-06
15	7.82E-05	3.07E-05	8.87E-07	2.07E-11	8.53E-11	3.58E-05	8.52E-06
20	7.88E-05	3.07E-05	9.60E-07	5.07E-11	9.21E-11	3.58E-05	9.27E-06
25	7.92E-05	3.07E-05	1.03E-06	1.18E-10	9.90E-11	3.59E-05	9.91E-06
30	7.93E-05	3.07E-05	1.09E-06	2.51E-10	1.05E-10	3.59E-05	1.04E-05
35	7.94E-05	3.07E-05	1.16E-06	4.68E-10	1.11E-10	3.59E-05	1.08E-05
40	7.96E-05	3.07E-05	1.22E-06	8.91E-10	1.17E-10	3.59E-05	1.11E-05
45	7.97E-05	3.07E-05	1.28E-06	1.96E-09	1.22E-10	3.60E-05	1.13E-05
50	7.98E-05	3.07E-05	1.35E-06	3.92E-09	1.29E-10	3.60E-05	1.15E-05
55	7.99E-05	3.07E-05	1.43E-06	7.47E-09	1.37E-10	3.60E-05	1.16E-05
60	8.01E-05	3.07E-05	1.52E-06	1.41E-08	1.45E-10	3.62E-05	1.17E-05
65	8.04E-05	3.07E-05	1.59E-06	2.79E-08	1.53E-10	3.65E-05	1.18E-05
70	8.08E-05	3.07E-05	1.69E-06	4.88E-08	1.62E-10	3.70E-05	1.18E-05
75	8.15E-05	3.07E-05	1.81E-06	8.18E-08	1.74E-10	3.78E-05	1.18E-05
80	8.33E-05	3.07E-05	1.94E-06	1.70E-07	1.86E-10	3.99E-05	1.19E-05
85	8.83E-05	3.07E-05	2.14E-06	3.95E-07	2.05E-10	4.53E-05	1.19E-05
90	1.01E-04	3.07E-05	2.38E-06	9.45E-07	2.28E-10	5.82E-05	1.19E-05
95	1.48E-04	3.07E-05	2.86E-06	2.83E-06	2.75E-10	1.04E-04	1.19E-05
Mean	9.24E-05	3.07E-05	1.52E-06	5.57E-07	1.46E-10	4.91E-05	1.06E-05
Max.	8.79E-04	3.07E-05	7.72E-06	3.25E-05	7.40E-10	8.08E-04	1.19E-05
95/50	1.85E+00	1.00E+00	2.12E+00	7.23E+02	2.12E+00	2.88E+00	1.03E+00
95-50	6.79E-05	1.00E-08	1.52E-06	2.83E-06	1.45E-10	6.77E-05	4.00E-07

Note: Any pathway with a 50th or 95th percentile peak dose that is more than 5 percent of the total peak dose of the same percentile is highlighted. Different colors are used in different rows.

Table B-36 Distributions of Peak Total Dose and Peak Pathway Dose Obtained with Probabilistic Calculations for the Building Occupancy Scenario Concerning Building Surface Contamination by Ra-228 (mrem/yr per pCi/m^2)

Percentile	Total	External	Inhalation	External Exposure from Deposition	Immersion	Ingestion	Radon
5	1.05E-04	2.03E-05	4.07E-06	1.66E-12	3.92E-11	3.77E-05	3.92E-05
10	1.14E-04	2.03E-05	4.72E-06	5.88E-12	4.55E-11	3.78E-05	4.67E-05
15	1.22E-04	2.03E-05	5.25E-06	1.35E-11	5.03E-11	3.78E-05	5.41E-05
20	1.30E-04	2.03E-05	5.63E-06	3.24E-11	5.37E-11	3.79E-05	6.19E-05
25	1.36E-04	2.03E-05	6.06E-06	7.61E-11	5.79E-11	3.79E-05	6.85E-05
30	1.42E-04	2.03E-05	6.51E-06	1.48E-10	6.20E-11	3.79E-05	7.42E-05
35	1.46E-04	2.03E-05	6.98E-06	2.39E-10	6.65E-11	3.79E-05	7.86E-05
40	1.50E-04	2.03E-05	7.39E-06	3.78E-10	7.03E-11	3.80E-05	8.22E-05
45	1.52E-04	2.03E-05	7.81E-06	5.70E-10	7.44E-11	3.80E-05	8.51E-05
50	1.54E-04	2.03E-05	8.21E-06	8.91E-10	7.82E-11	3.80E-05	8.70E-05
55	1.55E-04	2.03E-05	8.74E-06	1.38E-09	8.31E-11	3.80E-05	8.86E-05
60	1.56E-04	2.03E-05	9.24E-06	2.19E-09	8.77E-11	3.80E-05	8.96E-05
65	1.57E-04	2.03E-05	9.87E-06	3.62E-09	9.36E-11	3.81E-05	9.05E-05
70	1.58E-04	2.03E-05	1.05E-05	5.48E-09	9.93E-11	3.81E-05	9.10E-05
75	1.59E-04	2.03E-05	1.12E-05	8.70E-09	1.06E-10	3.83E-05	9.14E-05
80	1.60E-04	2.03E-05	1.21E-05	1.39E-08	1.14E-10	3.85E-05	9.17E-05
85	1.61E-04	2.03E-05	1.33E-05	2.15E-08	1.26E-10	3.88E-05	9.19E-05
90	1.62E-04	2.03E-05	1.50E-05	3.46E-08	1.41E-10	3.94E-05	9.21E-05
95	1.66E-04	2.03E-05	1.83E-05	5.84E-08	1.73E-10	4.04E-05	9.22E-05
Mean	1.46E-04	2.03E-05	9.32E-06	1.02E-08	8.85E-11	3.83E-05	7.80E-05
Max.	1.98E-04	2.03E-05	5.10E-05	1.68E-07	4.80E-10	4.49E-05	9.24E-05
95/50	1.08E+00	1.00E+00	2.23E+00	6.55E+01	2.21E+00	1.06E+00	1.06E+00
95-50	1.17E-05	1.00E-08	1.01E-05	5.75E-08	9.49E-11	2.40E-06	5.19E-06

Note: Any pathway with a 50th or 95th percentile peak dose that is more than 5 percent of the total peak dose of the same percentile is highlighted. Different colors are used in different rows.

Table B-37 Distributions of Peak Total Dose and Peak Pathway Dose Obtained with Probabilistic Calculations for the Building Occupancy Scenario Concerning Building Surface Contamination by Sr-90 (mrem/yr per pCi/m^2)

Percentile	Total	External	Inhalation	External Exposure from Deposition	Immersion	Ingestion	Radon
5	4.09E-06	1.03E-07	9.72E-08	8.45E-15	1.40E-13	3.84E-06	0.00E+00
10	4.11E-06	1.03E-07	1.13E-07	3.00E-14	1.62E-13	3.85E-06	0.00E+00
15	4.12E-06	1.03E-07	1.23E-07	6.95E-14	1.77E-13	3.85E-06	0.00E+00
20	4.13E-06	1.03E-07	1.32E-07	1.69E-13	1.90E-13	3.86E-06	0.00E+00
25	4.14E-06	1.03E-07	1.43E-07	3.96E-13	2.05E-13	3.86E-06	0.00E+00
30	4.15E-06	1.03E-07	1.52E-07	8.29E-13	2.18E-13	3.86E-06	0.00E+00
35	4.16E-06	1.03E-07	1.61E-07	1.51E-12	2.32E-13	3.86E-06	0.00E+00
40	4.18E-06	1.03E-07	1.71E-07	2.87E-12	2.46E-13	3.87E-06	0.00E+00
45	4.19E-06	1.03E-07	1.79E-07	5.59E-12	2.58E-13	3.87E-06	0.00E+00
50	4.20E-06	1.03E-07	1.89E-07	9.39E-12	2.71E-13	3.87E-06	0.00E+00
55	4.22E-06	1.03E-07	2.00E-07	1.58E-11	2.88E-13	3.87E-06	0.00E+00
60	4.24E-06	1.03E-07	2.14E-07	2.48E-11	3.07E-13	3.88E-06	0.00E+00
65	4.26E-06	1.03E-07	2.26E-07	4.15E-11	3.25E-13	3.89E-06	0.00E+00
70	4.29E-06	1.03E-07	2.39E-07	6.96E-11	3.44E-13	3.91E-06	0.00E+00
75	4.33E-06	1.03E-07	2.56E-07	1.18E-10	3.68E-13	3.95E-06	0.00E+00
80	4.39E-06	1.03E-07	2.77E-07	1.89E-10	3.98E-13	4.01E-06	0.00E+00
85	4.50E-06	1.03E-07	3.06E-07	3.57E-10	4.40E-13	4.14E-06	0.00E+00
90	4.71E-06	1.03E-07	3.41E-07	6.73E-10	4.91E-13	4.40E-06	0.00E+00
95	5.19E-06	1.03E-07	4.12E-07	1.31E-09	5.93E-13	4.90E-06	0.00E+00
Mean	4.34E-06	1.03E-07	2.14E-07	2.08E-10	3.08E-13	4.02E-06	0.00E+00
Max.	7.82E-06	1.03E-07	1.13E-06	4.57E-09	1.63E-12	7.50E-06	0.00E+00
95/50	1.23E+00	1.00E+00	2.19E+00	1.39E+02	2.19E+00	1.27E+00	NA
95-50	9.84E-07	1.00E-10	2.24E-07	1.30E-09	3.22E-13	1.03E-06	0.00E+00

Note: Any pathway with a 50th or 95th percentile peak dose that is more than 5 percent of the total peak dose of the same percentile is highlighted. Different colors are used in different rows.

Table B-38 Distributions of Peak Total Dose and Peak Pathway Dose Obtained with Probabilistic Calculations for the Building Occupancy Scenario Concerning Building Surface Contamination by Tc-99 (mrem/yr per pCi/m^2)

Percentile	7otal	External	Inhalation	External Exposure from Deposition	Immersion	Ingestion	Radon
5	3.94E-08	1.18E-09	7.01E-10	9.56E-17	1.30E-15	3.71E-08	0.00E+00
10	3.95E-08	1.18E-09	7.80E-10	3.39E-16	1.45E-15	3.72E-08	0.00E+00
15	3.96E-08	1.18E-09	8.46E-10	7.86E-16	1.57E-15	3.72E-08	0.00E+00
20	3.96E-08	1.18E-09	9.15E-10	1.93E-15	1.70E-15	3.73E-08	0.00E+00
25	3.97E-08	1.18E-09	9.83E-10	4.49E-15	1.82E-15	3.73E-08	0.00E+00
30	3.98E-08	1.18E-09	1.05E-09	9.54E-15	1.94E-15	3.73E-08	0.00E+00
35	3.99E-08	1.18E-09	1.11E-09	1.78E-14	2.05E-15	3.74E-08	0.00E+00
40	4.00E-08	1.18E-09	1.16E-09	3.39E-14	2.15E-15	3.74E-08	0.00E+00
45	4.01E-08	1.18E-09	1.21E-09	7.51E-14	2.25E-15	3.74E-08	0.00E+00
50	4.02E-08	1.18E-09	1.28E-09	1.49E-13	2.38E-15	3.74E-08	0.00E+00
55	4.04E-08	1.18E-09	1.37E-09	2.85E-13	2.54E-15	3.75E-08	0.00E+00
60	4.07E-08	1.18E-09	1.45E-09	5.53E-13	2.68E-15	3.77E-08	0.00E+00
65	4.10E-08	1.18E-09	1.52E-09	1.09E-12	2.82E-15	3.80E-08	0.00E+00
70	4.15E-08	1.18E-09	1.61E-09	1.95E-12	2.99E-15	3.86E-08	0.00E+00
75	4.24E-08	1.18E-09	1.73E-09	3.35E-12	3.20E-15	3.96E-08	0.00E+00
80	4.46E-08	1.18E-09	1.85E-09	6.95E-12	3.43E-15	4.20E-08	0.00E+00
85	5.13E-08	1.18E-09	2.03E-09	1.65E-11	3.78E-15	4.85E-08	0.00E+00
90	6.79E-08	1.18E-09	2.26E-09	4.06E-11	4.20E-15	6.54E-08	0.00E+00
95	1.28E-07	1.18E-09	2.73E-09	1.28E-10	5.07E-15	1.25E-07	0.00E+00
Mean	6.12E-08	1.18E-09	1.45E-09	3.08E-11	2.69E-15	5.85E-08	0.00E+00
Max.	1.71E-06	1.18E-09	7.30E-09	2.42E-09	1.36E-14	1.71E-06	0.00E+00
95/50	3.17E+00	1.00E+00	2.13E+00	8.57E+02	2.13E+00	3.35E+00	NA
95-50	8.74E-08	0.00E+00	1.45E-09	1.27E-10	2.68E-15	8.79E-08	0.00E+00

Note: Any pathway with a 50th or 95th percentile peak dose that is more than 5 percent of the total peak dose of the same percentile is highlighted. Different colors are used in different rows.

Table B-39 Distributions of Peak Total Dose and Peak Pathway Dose Obtained with Probabilistic Calculations for the Building Occupancy Scenario Concerning Building Surface Contamination by U-238 (mrem/yr per pCi/m^2)

Percentile	Total	External	Inhalation	External Exposure from Deposition	Immersion	Ingestion	Radon
5	1.78E-05	5.57E-07	9.95E-06	4.59E-14	1.10E-12	6.83E-06	3.09E-21
10	1.90E-05	5.57E-07	1.11E-05	1.63E-13	1.22E-12	6.85E-06	3.52E-21
15	2.00E-05	5.57E-07	1.20E-05	3.78E-13	1.32E-12	6.85E-06	3.91E-21
20	2.10E-05	5.57E-07	1.30E-05	9.25E-13	1.43E-12	6.86E-06	4.26E-21
25	2.21E-05	5.57E-07	1.39E-05	2.16E-12	1.54E-12	6.87E-06	4.55E-21
30	2.30E-05	5.57E-07	1.48E-05	4.58E-12	1.64E-12	6.87E-06	4.79E-21
35	2.39E-05	5.57E-07	1.57E-05	8.57E-12	1.73E-12	6.88E-06	4.97E-21
40	2.48E-05	5.57E-07	1.64E-05	1.63E-11	1.81E-12	6.88E-06	5.10E-21
45	2.58E-05	5.57E-07	1.72E-05	3.61E-11	1.90E-12	6.89E-06	5.20E-21
50	2.71E-05	5.57E-07	1.82E-05	7.16E-11	2.01E-12	6.89E-06	5.28E-21
55	2.82E-05	5.57E-07	1.94E-05	1.37E-10	2.14E-12	6.90E-06	5.34E-21
60	2.94E-05	5.57E-07	2.05E-05	2.66E-10	2.26E-12	6.93E-06	5.37E-21
65	3.09E-05	5.57E-07	2.15E-05	5.22E-10	2.37E-12	7.00E-06	5.40E-21
70	3.25E-05	5.57E-07	2.29E-05	9.39E-10	2.52E-12	7.11E-06	5.42E-21
75	3.45E-05	5.57E-07	2.45E-05	1.61E-09	2.70E-12	7.29E-06	5.44E-21
80	3.71E-05	5.57E-07	2.62E-05	3.35E-09	2.90E-12	7.73E-06	5.45E-21
85	4.01E-05	5.57E-07	2.89E-05	7.93E-09	3.18E-12	8.93E-06	5.45E-21
90	4.49E-05	5.57E-07	3.21E-05	1.95E-08	3.54E-12	1.20E-05	5.46E-21
95	5.72E-05	5.57E-07	3.87E-05	6.14E-08	4.27E-12	2.31E-05	5.46E-21
Mean	3.19E-05	5.57E-07	2.05E-05	1.49E-08	2.27E-12	1.08E-05	4.88E-21
Max.	3.46E-04	5.57E-07	1.04E-04	1.17E-06	1.14E-11	3.16E-04	5.47E-21
95/50	2.11E+00	1.00E+00	2.13E+00	8.58E+02	2.13E+00	3.35E+00	1.03E+00
95-50	3.01E-05	2.00E-10	2.05E-05	6.13E-08	2.26E-12	1.62E-05	1.84E-22

Note: Any pathway with a 50th or 95th percentile peak dose that is more than 5 percent of the total peak dose of the same percentile is highlighted. Different colors are used in different rows.

Table B-40 Dominant Exposure Pathways at 50th and 95th Dose Percentiles for Building Occupancy Scenario

Radionuclide	Probabilistic Results: Table	Probabilistic Results: Percentile 50	Probabilistic Results: Percentile 95	Deterministic results from Table B-27	Comments
C-14	B-28	Ingestion	Ingestion	Ingestion	The absolute dose variability in the peak total dose is mainly associated with variability in ingestion pathway as shown in the last row in Table B-28.
Co-60	B-29	Direct external	Direct external	Direct external	The peak total dose has practically no relative variability (i.e., ratio of peak dose at 95 percent to 50 percent is 1.0). The absolute dose variability in the peak dose is mainly associated with variability in external exposure from deposition, ingestion, inhalation, and direct external exposure pathways as shown in the last row in Table B-29.
Cs-137	B-30	Direct external Ingestion	Direct external Ingestion	Direct external Ingestion	The peak total dose has very small relative variability (i.e., ratio of peak dose at 95 percent to 50 percent is 1.04). The absolute dose variability in the peak dose is associated with variability in external exposure from deposition and ingestion pathways as shown in the last row in Table B-30.
H-3	B-31	Ingestion	Ingestion	Ingestion Inhalation	The absolute dose variability in the peak dose is mainly associated with variability in ingestion and inhalation pathways as shown in the last row in Table B-31.
I-129	B-32	Ingestion Direct external	Ingestion	Ingestion Direct external	The absolute dose variability in the peak dose is mainly associated with variability in ingestion pathway as shown in the last row in Table B-32.
Np-237	B-33	Ingestion Inhalation	Ingestion Inhalation	Inhalation Ingestion	The absolute dose variability in the peak dose is mainly associated with variability in ingestion and inhalation pathways as shown in the last row in Table B-33.
Pu-239	B-34	Ingestion Inhalation	Ingestion Inhalation	Inhalation Ingestion	The absolute dose variability in the peak dose is mainly associated with variability in ingestion and inhalation pathways as shown in the last row in Table B-34.
Ra-226	B-35	Radon inhalation Direct external Ingestion	Radon inhalation Direct external Ingestion	Ingestion Direct external Radon inhalation	The absolute dose variability in the peak dose is mainly associated with variability in ingestion pathway as shown in the last row in Table B-35.
Ra-228	B-36	Radon inhalation Ingestion Direct external Inhalation	Radon inhalation Ingestion Direct external Inhalation	Radon inhalation Ingestion Inhalation Direct external	The absolute dose variability in the peak dose is mainly associated with variability in inhalation, radon inhalation, and ingestion exposure pathways as shown in the last row in Table B-36.
Sr-90	B-37	Ingestion	Ingestion Inhalation	Inhalation Ingestion	The absolute dose variability in the peak dose is mainly associated with variability in ingestion and inhalation exposure pathways as shown in the last row in Table B-37.
Tc-99	B-38	Ingestion	Ingestion	Ingestion Inhalation	The absolute dose variability in the peak dose is mainly associated with variability in ingestion pathway as shown in the last row in Table B-38.
U-238	B-39	Inhalation Ingestion	Inhalation Ingestion	Inhalation Ingestion	The absolute dose variability in the peak dose is mainly associated with variability in inhalation and ingestion pathways as shown in the last row in Table B-39.

Note: For deterministic analysis, any pathway with a peak dose that is more than 5 percent of the peak total dose was considered significant in this analysis. For probabilistic analysis, any pathway with 50th or 95th percentile dose that is more than 5 percent of the 50th or 95th percentile dose, respectively from total dose was considered significant in this analysis.

Table B-41 Summary of Regression Analysis to Identify Sensitive Parameters that Influence the Peak Total Dose for the Building Occupancy Scenario

C-14 Regression Coefficients for Peak All Pathways			
Repetition =	1	2	3
Coefficient of determination (R-squared) =	0.88	0.89	0.89
Description of probabilistic variable	SRRC	SRRC	SRRC
Resuspension rate	-0.84	-0.85	-0.83
Deposition velocity	0.38	0.38	0.39
Co-60 Regression Coefficients for Peak All Pathways			
Repetition =	1	2	3
Coefficient of determination (R-squared) =	0.68	0.69	0.68
Description of probabilistic Variable	SRRC	SRRC	SRRC
Deposition velocity	0.55	0.54	0.53
Resuspension rate	-0.51	-0.5	-0.53
Release time of source 1	0.29	0.32	0.26
Release time of source 3	-0.06	-0.1	-0.13
Release time of source 4	-0.09	-0.08	-0.11
Release time of source 5	-0.09	-0.11	-0.01
Cs-137 Regression Coefficients for Peak All Pathways			
Repetition =	1	2	3
Coefficient of determination (R-squared) =	0.72	0.71	0.71
Description of probabilistic variable	SRRC	SRRC	SRRC
Resuspension rate	-0.66	-0.66	-0.67
Deposition velocity	0.48	0.48	0.47
Release time of source 1	0.14	0.17	0.13
Release time of source 2	0.11	0.11	0.11
H-3 Regression Coefficients for Peak All Pathways			
Repetition =	1	2	3
Coefficient of determination (R-squared) =	0.76	0.74	0.71
Description of probabilistic Variable	SRRC	SRRC	SRRC
Resuspension rate	-0.55	-0.55	-0.57
Deposition velocity	0.48	0.49	0.46
Release time of source 2	-0.28	-0.29	-0.25
Release time of source 1	-0.25	-0.25	-0.26
Release time of source 3	-0.09	-0.13	-0.14
Release time of source 5	-0.12	-0.1	-0.11
Note: For identifying parameters that impact the peak total dose, a cut-off value of 0.1 was subjectively selected for the SRRC.			

Table B-41 Summary of Regression Analysis to Identify Sensitive Parameters that Influence the Peak Total Dose for the Building Occupancy Scenario (cont.)

I-129 Regression Coefficients for Peak All Pathways			
Repetition =	1	2	3
Coefficient of determination (R-squared) =	0.84	0.84	0.83
Description of probabilistic variable	SRRC	SRRC	SRRC
Resuspension rate	-0.81	-0.82	-0.81
Deposition velocity	0.37	0.36	0.37
Release time of source 1	0.1	0.11	0.1
Release time of source 2	0.11	0.1	0.1
Np-237 Regression Coefficients for Peak All Pathways			
Repetition =	1	2	3
Coefficient of determination (R-squared) =	0.62	0.6	0.62
Description of probabilistic variable	SRRC	SRRC	SRRC
Release time of source 2	-0.42	-0.41	-0.41
Release time of source 1	-0.38	-0.39	-0.42
Resuspension rate	-0.36	-0.34	-0.32
Deposition velocity	0.22	0.23	0.20
Release time of source 5	-0.20	-0.15	-0.19
Release time of source 3	-0.16	-0.16	-0.18
Release time of source 4	-0.18	-0.15	-0.19
Release time of source 6	-0.14	-0.19	-0.18
Pu-239 Regression Coefficients for Peak All Pathways			
Repetition =	1	2	3
Coefficient of determination (R-squared) =	0.62	0.6	0.62
Description of probabilistic variable	SRRC	SRRC	SRRC
Release time of source 2	-0.42	-0.41	-0.41
Release time of source 1	-0.38	-0.39	-0.42
Resuspension rate	-0.36	-0.34	-0.32
Deposition velocity	0.22	0.23	0.20
Release time of source 5	-0.20	-0.15	-0.19
Release time of source 3	-0.16	-0.16	-0.18
Release time of source 4	-0.18	-0.15	-0.19
Release time of source 6	-0.14	-0.19	-0.18
Ra-226 Regression Coefficients for Peak All Pathways			
Repetition =	1	2	3
Note: For identifying parameters that impact the peak total dose, a cut-off value of 0.1 was subjectively selected for the SRRC.			

Table B-41 Summary of Regression Analysis to Identify Sensitive Parameters that Influence the Peak Total Dose for the Building Occupancy Scenario (cont.)

Ra-226 Regression Coefficients for Peak All Pathways (cont.)			
Coefficient of determination (R-squared) =	0.6	0.56	0.59
Description of probabilistic variable	SRRC	SRRC	SRRC
Resuspension rate	-0.71	-0.68	-0.70
Release time of source 2	-0.19	-0.17	-0.17
Deposition velocity	-0.16	-0.15	-0.19
Release time of source 1	-0.15	-0.16	-0.17
Ra-228 Regression Coefficients for Peak All Pathways			
Repetition =	1	2	3
Coefficient of determination (R-squared) =	0.86	0.86	0.86
Description of probabilistic variable	SRRC	SRRC	SRRC
Deposition velocity	-0.88	-0.87	-0.88
Release time of source 2	-0.19	-0.18	-0.19
Release time of source 1	-0.17	-0.18	-0.16
Sr-90 Regression Coefficients for Peak All Pathways			
Repetition =	1	2	3
Coefficient of determination (R-squared) =	0.69	0.65	0.66
Description of probabilistic variable	SRRC	SRRC	SRRC
Resuspension rate	-0.46	-0.43	-0.43
Deposition velocity	0.37	0.37	0.35
Release time of source 2	-0.37	-0.37	-0.35
Release time of source 1	-0.33	-0.34	-0.37
Release time of source 3	-0.14	-0.15	-0.17
Release time of source 4	-0.15	-0.12	-0.17
Release time of source 5	-0.16	-0.13	-0.15
Release time of source 6	-0.11	-0.15	-0.13
Tc-99 Regression Coefficients for Peak All Pathways			
Repetition =	1	2	3
Coefficient of determination (R-squared) =	0.71	0.74	0.74
Description of probabilistic variable	SRRC	SRRC	SRRC
Resuspension rate	-0.96	-0.91	-1.23
Deposition velocity	0.50	0.46	0.80
Release time of source 1	-0.36	-0.41	-0.33
Release time of source 2	-0.39	-0.30	-0.37
Note: For identifying parameters that impact the peak total dose, a cut-off value of 0.1 was subjectively selected for the SRRC.			

Table B-41 Summary of Regression Analysis to Identify Sensitive Parameters that Influence the Peak Total Dose for the Building Occupancy Scenario (cont.)

Tc-99 Regression Coefficients for Peak All Pathways (cont.)			
Release time of source 5	-0.25	-0.24	-0.13
Release time of source 4	-0.17	-0.16	-0.16
Release time of source 3	-0.15	-0.20	-0.09
Release time of source 6	-0.06	-0.18	-0.19
U-238 Regression Coefficients for Peak All Pathways			
Repetition =	1	2	3
Coefficient of determination (R-squared) =	0.64	0.62	0.65
Description of probabilistic variable	SRRC	SRRC	SRRC
Release time of source 1	-0.43	-0.44	-0.47
Release time of source 2	-0.48	-0.46	-0.46
Resuspension rate	-0.24	-0.22	-0.19
Release time of source 4	-0.21	-0.18	-0.20
Release time of source 5	-0.22	-0.17	-0.21
Release time of source 6	-0.16	-0.22	-0.20
Release time of source 3	-0.16	-0.18	-0.20
Deposition velocity	0.16	0.16	0.13
Note: For identifying parameters that impact the peak total dose, a cut-off value of 0.1 was subjectively selected for the SRRC.			

B.3 Offsite Resident via Water Transport Scenario

The purpose of this analysis was to illustrate the use of the probabilistic RESRAD-OFFSITE code to simulate the water transport scenario as described in Section 4. The probabilistic analysis was performed to identify parameters that have significant effect on peak total dose. In a probabilistic analysis, behavioral parameters were kept at a fixed value and physical parameters were assigned distributions. Only parameters associated with parent radionuclide were assigned distributions. Table B-42 lists the input parameters of the RESRAD-OFFSITE code, their base value used in the deterministic calculations, and their statistical distribution (including the distribution function and the associated distribution parameters) used in the probabilistic calculations. Radionuclide or element specific input parameters are listed in separate tables. Tables B-3 through B-8 list point values and statistical distributions for the plant transfer factor, meat transfer factor, milk transfer factor, fish bioaccumulation factor, crustacean bioaccumulation factor, and K_d, respectively.

For each probabilistic analysis, input data sets were generated with the specifications of 2,000 observations, three repetitions, and the Latin Hypercube Sampling (LHS) technique. After the probabilistic calculations were completed, the dose results obtained with all input data sets were analyzed by the RESRAD-OFFSITE code, and the average, minimum, maximum, and percentiles of the peak total dose and the peak pathway dose were reported. Tables B-43 through B-54 list the reported results for the Offsite Resident via Water Transport scenario for each of the 12 radionuclides selected for evaluation. In the probabilistic analysis, there is a distribution of peak total dose and distribution of peak pathway doses from different simulations. The peak pathway dose may or may not occur at the same time as the peak total dose. To analyze the results two variability criteria: ratio of peak dose at 95 to 50 percentile and difference of peak dose at 95 percent to peak dose at 50 percent were used. The ratio would give the relative variability and the difference would give the absolute variability. Pathways associated with water release mechanism had smaller relative variability in the peak total dose distribution compared with pathways associated with exposure directly from primary contamination and from air release to the atmosphere.

The dominant exposure pathways in this analysis were identified by comparing the peak pathway dose at two percentiles (50 percent and 95 percent) to the peak total dose at the same percentiles. Any pathway with a peak dose that is more than 5 percent of the peak dose from all pathways is defined as a dominant exposure pathway. Because of the differences in the ratio of peak dose at 95 percent to 50 percent percentile in exposure pathway, the dominant exposure pathways at 50 percent may be different than the dominant exposure pathways at 95 percent. The dominant exposure pathways at 50 percent and 95 percent are highlighted in Tables B.43 through B-54. Table B-55 lists dominant exposure pathways for 50 and 95 dose percentiles.

RESRAD-OFFSITE has two aids to help identify the significant inputs: a regression report with the inputs sorted in descending order of significance and scatter plots of output against inputs. The regression analysis was performed on both raw and ranked data. The code compared the coefficients of determination for the regression on the raw data and the regression on the ranked data. The coefficient of determination measured how well a regression modeled the variation in the output (peak predicted dose). The absolute values of the standardized regression coefficients of the regression, raw or ranked, that had the higher coefficient of determination were used to sort the inputs in descending order of influence.

For identifying parameters that impact the peak total dose, a cut-off value of 0.05 was subjectively selected for the SRRC, judging by the range of SRRC from all input parameters. The selection of a low cut-off value allows more input parameters to be identified that influence the total dose. Table B-56 summarizes the regression analysis results for the Offsite Resident via Water Transport scenario. The influence of a parameter is categorized subjectively into three groups: SRRC >0.2 (high influence on dose), SRRC in the range ≥0.1 to 0.2 (medium influence on dose), and SRRC in the range ≥0.05 to <0.1 (low influence on dose). The SRRC cutoff value and its range for categorizing input parameters are not absolute; they depend on the regression analysis results of each run and should be judged by the analyst. The cutoff value can be verified by another run as described in Section 4.3 and attachment C.4.4 of NUREG/CR-7127 (Yu et al. 2013).

The parameters that impact the total dose for each radionuclide as listed in Table B-56 match the dominant exposure pathways identified in Table B-55. The parameters that impact the dose are used in modeling the radiation dose associated with the dominant exposure pathways, thereby influencing the total dose.

Table B-42 Base Values and Statistical Distributions of Input Parameters Used in the RESRAD-OFFSITE Code for the Offsite Resident via Water Transport Scenario

Input screen title/parameter	Units	Type[b]	Base value for deterministic calculation	Source	Probabilistic analysis[a]					Description
					Distribution	Parameter 1	Parameter 2	Parameter 3	Parameter 4	
Title and Radiological Data										
Title	—[c]	NA[c]	RESRAD-OFFSITE Water transport scenario	Scenario specific	None	NR[d]	NR	NR	NR	The Title is used to identify the run and can be up to 80 alphabetic or numerical characters long.
Location of dose, slope, and transfer factor database	—	NA	C:\RESRAD_FAMILY\DCF\3.1	Code default	None	NR	NR	NR	NR	The location of the dose factor library containing all dose coefficients, slope factors, and transfer factors for the RESRAD-OFFSITE pathways.
Radionuclide transformation based on	—	NA	ICRP 107	Code default	None	NR	NR	NR	NR	The code has the option to select ICRP 107 or ICRP 38 radionuclide transformation database.
External exposure library	—	NA	DCFPAK 3.02	Code default	None	NR	NR	NR	NR	External exposure factor library used.
Internal exposure dose library	—	NA	DOE STD-1196-2011 (reference person)	Code default	None	NR	NR	NR	NR	Internal exposure factor library used.
Slope factor (risk) library	—	NA	DCFPAK 3.02 Morbidity	Code default	None	NR	NR	NR	NR	Slope factor (risk) library used
Transfer factor library	—	NA	RESRAD default transfer factor	Code default	None	NR	NR	NR	NR	Transfer factor library used.
Cutoff half-life	days	NA	30	Code default	None	NR	NR	NR	NR	The cutoff half-life used to separate the "principal nuclides" from the "associated nuclides."

[a] For truncated lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution, parameter 3 = lower quantile, and parameter 4 = upper quantile; for lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution; for triangular distribution, parameter 1 = minimum, parameter 2 = mode or most likely, and parameter 3 = maximum; for truncated normal distribution, parameter 1 = mean, parameter 2 = standard deviation, parameter 3 = lower quantile, and parameter 4 = upper quantile; for bounded lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution, parameter 3 = minimum value, and parameter 4 = maximum value; for uniform distribution, , parameter 1 = minimum, and parameter 2 = maximum; for continuous linear distribution, number of points, value of points, and CDF of points; for continuous logarithmic distribution, number of points, value of points, and CDF of points.

[b] P = physical, B = behavioral, and M = metabolic parameter.

[c] NA = not applicable.

[d] NR = not required.

Table B-42 Base Values and Statistical Distributions of Input Parameters Used in the RESRAD-OFFSITE Code for the Offsite Resident via Water Transport Scenario (cont.)

Input screen title/parameter	Units	Type[b]	Base value for deterministic calculation	Source	Probabilistic analysis[a]					Description
					Distribution	Parameter 1	Parameter 2	Parameter 3	Parameter 4	
Title and Radiological Data (cont.)										
Number of points	—	NA	1024, 2048, 4096, 22,000	Selected value	None	NR	NR	NR	NR	This parameter specifies the number of graphic points. It affects the precision of the computed results and the smoothness of the output graphic curves. To accurately model the rapidly changing evasion losses for C-14, the number of points used were 22,000. For other radionuclides, the number of points used varied from 1024 to 4096 depending on the last reporting time used in the analysis.
Linear spacing/log spacing	—	NA	Linear spacing	Selected value	None	NR	NR	NR	NR	Linear or log is to specify the type of spacing (years) between the generated time points
Minimum time increment between points	year	NA	1	Code default	None	NR	NR	NR	NR	Only applicable when log spacing is selected. The lowest time interval allowed between two intermediate time points. It is also used to determine the secondary intermediate time point.
Update progress of computation message every	seconds	NA	0.0	Code default	None	NR	NR	NR	NR	An interface parameter that specifies how frequently the progress of computation is to be reported and displayed on the screen.
Save input file when a form is saved	—	NA	Not checked	Code default	None	NR	NR	NR	NR	Clicking on this check box saves input file when a form is saved.
Use line draw character	—	NA	Checked	Code default	None	NR	NR	NR	NR	Use line-draw character set in the report files.

[a] For truncated lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution, parameter 3 = lower quantile, and parameter 4 = upper quantile; for lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution; for triangular distribution, parameter 1 = minimum, parameter 2 = mode or most likely, and parameter 3 = maximum; for truncated normal distribution, parameter 1 = mean, parameter 2 = standard deviation, parameter 3 = lower quantile, and parameter 4 = upper quantile; for bounded lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution, parameter 3 = minimum value, and parameter 4 = maximum value; for uniform distribution, , parameter 1 = minimum, and parameter 2 = maximum; for continuous linear distribution, number of points, value of points, and CDF of points; for continuous logarithmic distribution, number of points, value of points, and CDF of points.

[b] P = physical, B = behavioral, and M = metabolic parameter.

[c] NA = not applicable.

[d] NR = not required.

Table B-42 Base Values and Statistical Distributions of Input Parameters Used in the RESRAD-OFFSITE Code for the Offsite Resident via Water Transport Scenario (cont.)

Input screen title/parameter	Units	Type[b]	Base value for deterministic calculation	Source	Probabilistic analysis[a]					Description
					Distribution	Parameter 1	Parameter 2	Parameter 3	Parameter 4	
Preliminary inputs										
Radiological units for activity	—	NA	pCi	Code default	None	NR	NR	NR	NR	Any of the four units of radioactivity: Curie (Ci), Becquerel (Bq), disintegrations per second (dps), or disintegrations per minute (dpm) can be selected. Any standard 1-character metric prefix can be used with Ci and Bq. In this analysis conventional unit was used,
Radiological units for dose	—	NA	mrem	Code default	None	NR	NR	NR	NR	Both conventional and SI units may be selected for radiation dose. In this analysis, conventional units were used.
Basic radiation dose limit	mrem/yr	NA	25	Code default	None	NR	NR	NR	NR	The annual radiation dose limit in mrem/yr used to derive all site-specific guidelines. Guidelines not derived in this analysis.
Exposure duration (for risk)	year	NA	30	Code default	None	NR	NR	NR	NR	The exposure duration is the span of time in years an individual spends at the exposure location for risk calculations. Risk calculations not used in this analysis.
Number of unsaturated zone	—	P	1	Code default	None	NR	NR	NR	NR	Number of unsaturated zones. An unsaturated zone is a horizontal uncontaminated layer located between the contaminated zone and the aquifer.
Submerged fraction of primary contamination	—	P	0	Code default	None	NR	NR	NR	NR	Value greater than 0 indicates that part or all of primary contamination is below the water table.
Conceptualization of primary contamination	—	P	Specify initial activity based on mass of entire primary contamination	Scenario assumption	None	NR	NR	NR	NR	The choice for conceptualization of primary contamination.
Default release mechanism	—	P	First order rate-controlled release	Scenario assumption	None	NR	NR	NR	NR	This is the default release mechanism selected for the source.

[a] For truncated lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution, parameter 3 = lower quantile, and parameter 4 = upper quantile; for lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution; for triangular distribution, parameter 1 = minimum, parameter 2 = mode or most likely, and parameter 3 = maximum; for truncated normal distribution, parameter 1 = mean, parameter 2 = standard deviation, parameter 3 = lower quantile, and parameter 4 = upper quantile; for bounded lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution, parameter 3 = minimum value, and parameter 4 = maximum value; for uniform distribution, , parameter 1 = minimum, and parameter 2 = maximum; for continuous linear distribution, number of points, value of points, and CDF of points; for continuous logarithmic distribution, number of points, value of points, and CDF of points.

[b] P = physical, B = behavioral, and M = metabolic parameter.

[c] NA = not applicable.

[d] NR = not required.

Table B-42 Base Values and Statistical Distributions of Input Parameters Used in the RESRAD-OFFSITE Code for the Offsite Resident via Water Transport Scenario (cont.)

Input screen title/parameter	Units	Type[b]	Base value for deterministic calculation	Source	Probabilistic analysis[a]					Description
					Distribution	Parameter 1	Parameter 2	Parameter 3	Parameter 4	
Preliminary inputs (cont.)										
Maximum number of iterations for Solubility release	—	NA	Not used	Not used	None	NR	NR	NR	NR	Not used for first order rate-controlled release.
Times at which release properties change										
First time at which the GW release begins	year	P	0	For deterministic run release begins at time zero and for probabilistic run a uniform distribution from time zero to 100 years is assumed	Uniform	0	100	NA	NA	First time at which release begins.
Second time at which release changes	year	p	200	For deterministic run release changes at 200 years and for probabilistic run a uniform distribution from time 100 to 300 years is assumed	Uniform	100	300	NA	NA	Second time at which release properties change.
Number of times at which the release properties change	—	P	2	Assumption	None	NR	NR	NR	NR	The code allows maximum of nine times. Carried to source release form.
Source										
Nuclide concentration	pCi/g	P	1	Assumption	None	NR	NR	NR	NR	The radionuclide concentration in the contaminated zone. The contaminated zone is a uniformly contaminated area with a single radionuclide concentration at every point.

[a] For truncated lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution, parameter 3 = lower quantile, and parameter 4 = upper quantile; for lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution; for triangular distribution, parameter 1 = minimum, parameter 2 = mode or most likely, and parameter 3 = maximum; for truncated normal distribution, parameter 1 = mean, parameter 2 = standard deviation, parameter 3 = lower quantile, and parameter 4 = upper quantile; for bounded lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution, parameter 3 = minimum value, and parameter 4 = maximum value; for uniform distribution, , parameter 1 = minimum, and parameter 2 = maximum; for continuous linear distribution, number of points, value of points, and CDF of points; for continuous logarithmic distribution, number of points, value of points, and CDF of points.

[b] P = physical, B = behavioral, and M = metabolic parameter.

[c] NA = not applicable.

[d] NR = not required.

Table B-42 Base Values and Statistical Distributions of Input Parameters Used in the RESRAD-OFFSITE Code for the Offsite Resident via Water Transport Scenario (cont.)

Input screen title/parameter	Units	Type[b]	Base value for deterministic calculation	Source	Probabilistic analysis[a] Distribution	Parameter 1	Parameter 2	Parameter 3	Parameter 4	Description
Source release To be input for all nuclides.										
Release to groundwater										
Release mechanism	—	P	First order rate-controlled release	Assumption	None	NR	NR	NR	NR	Release mechanisms available depend on the selection in the Preliminary Input form.
Times at which release begins or changes	year	P	0, 200	Described earlier in this table under the entries for the "Times at which release properties change" form						Parameter is carried from the Release Times form.
Cumulative fraction of radionuclide bearing material releasable at different release times	—	P	0.5, 1	Assumption	None	NR	NR	NR	NR	The code conceptualizes two forms of nuclide bearing material: a release susceptible form and a release immune form. The nuclide bearing material that is protected by engineering barriers and containers can initially be in the release immune form for a period of time. Thereafter, some or all of the nuclide bearing material can change to the release susceptible form as the engineered barriers and containers deteriorate over time. To be input for all radionuclides.

[a] For truncated lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution, parameter 3 = lower quantile, and parameter 4 = upper quantile; for lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution; for triangular distribution, parameter 1 = minimum, parameter 2 = mode or most likely, and parameter 3 = maximum; for truncated normal distribution, parameter 1 = mean, parameter 2 = standard deviation, parameter 3 = lower quantile, and parameter 4 = upper quantile; for bounded lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution, parameter 3 = minimum value, and parameter 4 = maximum value; for uniform distribution, , parameter 1 = minimum, and parameter 2 = maximum; for continuous linear distribution, number of points, value of points, and CDF of points; for continuous logarithmic distribution, number of points, value of points, and CDF of points.

[b] P = physical, B = behavioral, and M = metabolic parameter.

[c] NA = not applicable.

[d] NR = not required.

Table B-42 Base Values and Statistical Distributions of Input Parameters Used in the RESRAD-OFFSITE Code for the Offsite Resident via Water Transport Scenario (cont.)

Input screen title/parameter	Units	Type[b]	Base value for deterministic calculation	Source	Probabilistic analysis[a]					Description
					Distribution	Parameter 1	Parameter 2	Parameter 3	Parameter 4	
Source release To be input for all nuclides.										
Release to groundwater										
Incremental fraction of radionuclide bearing material becomes releasable at different release times	—	P	Stepwise at time, linearly over time	Assumption	None	NR	NR	NR	NR	Two release options, linearly overtime and stepwise in time, are available. If linearly over time option is chosen, the releasable fraction is modeled as varying linearly from the initial value to the final value over the time over which the release immune phase transforms to the release susceptible phase. If step wise is chosen, the nuclides in the initial releasable fraction are modeled as being released at the initial leach rate while the nuclides in the nuclide bearing material that became releasable later are released at the final leach rate. This scenario assumes the first time release is stepwise at time and the 2[nd] time release is linearly over time.
Leach rate	1/yr	P	0.001, 0.01	Assumption	None	NR	NR	NR	NR	First time release rate is small and second time release rate is ten times higher.
Leach rate of isotope changes	1/y	P	Stepwise at time, linearly over time	Assumption	None	NR	NR	NR	NR	First time release rate changes stepwise at time and second time it changes linearly with time.
Release from surface layer										
Radionuclide becomes available for release	—	P	In the same manner as for release to groundwater	Assumption	None	NR	NR	NR	NR	Two options, in the same manner as for release to groundwater and beginning at time zero, are available.
Distribution coefficients To be input for all nuclides.										
Contaminated medium	cm^3/g	P	NR	NR	NR	NR	NR	NR	NR	Distribution coefficient for contaminated medium not required in this scenario.

[a] For truncated lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution, parameter 3 = lower quantile, and parameter 4 = upper quantile; for lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution; for triangular distribution, parameter 1 = minimum, parameter 2 = mode or most likely, and parameter 3 = maximum; for truncated normal distribution, parameter 1 = mean, parameter 2 = standard deviation, parameter 3 = lower quantile, and parameter 4 = upper quantile; for bounded lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution, parameter 3 = minimum value, and parameter 4 = maximum value; for uniform distribution, , parameter 1 = minimum, and parameter 2 = maximum; for continuous linear distribution, number of points, value of points, and CDF of points; for continuous logarithmic distribution, number of points, value of points, and CDF of points.

[b] P = physical, B = behavioral, and M = metabolic parameter.

[c] NA = not applicable.

[d] NR = not required.

Table B-42 Base Values and Statistical Distributions of Input Parameters Used in the RESRAD-OFFSITE Code for the Offsite Resident via Water Transport Scenario (cont.)

Input screen title/parameter	Units	Type[b]	Base value for deterministic calculation	Source	Probabilistic analysis[a]					Description
					Distribution	Parameter 1	Parameter 2	Parameter 3	Parameter 4	
Distribution coefficients (cont.) To be input for all nuclides.										
Contaminated medium	cm^3/g	P	NR	NR	NR	NR	NR	NR	NR	Distribution coefficient for contaminated medium not required in this scenario.
Contaminated zone	cm^3/g	P	See Table B-8	The selected values are from Table 2.13.9 in Data Collection Handbook (Yu et al. 2015). The base values are the values for the generic soil type. The distributions are for the generic soil type.	for all truncated lognormal-n	Table B-8	Table B-8	Table B-8	Table B-8	Site-specific values should be used everywhere for each radionuclide. Default values and distributions are provided by the code for most radionuclides.However, these values should be used with care because distribution coefficients can vary over many orders of magnitude.
Unsaturated zone	cm^3/g	P	See Table B-8	Same as above	Same as above	Same as above	Same as above	Same as above	Same as above	Same as above
Saturated zone	cm^3/g	P	See Table B-8	Same as above	Same as above	Same as above	Same as above	Same as above	Same as above	Same as above
Suspended sediment in surface water body	cm^3/g	P	See Table B-8	Same as above	Same as above	Same as above	Same as above	Same as above	Same as above	Same as above
Bottom sediment in surface water body	cm^3/g	P	See Table B-8	Same as above	Same as above	Same as above	Same as above	Same as above	Same as above	Same as above
Fruit, grain, non-leafy fields	cm^3/g	P	See Table B-8	For deterministic run, base values are from Table 2.13.9 in Data Collection Handbook (Yu et al. 2015).	None	NR	NR	NR	NR	Same as above

[a] For truncated lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution, parameter 3 = lower quantile, and parameter 4 = upper quantile; for lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution; for triangular distribution, parameter 1 = minimum, parameter 2 = mode or most likely, and parameter 3 = maximum; for truncated normal distribution, parameter 1 = mean, parameter 2 = standard deviation, parameter 3 = lower quantile, and parameter 4 = upper quantile; for bounded lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution, parameter 3 = minimum value, and parameter 4 = maximum value; for uniform distribution, , parameter 1 = minimum, and parameter 2 = maximum; for continuous linear distribution, number of points, value of points, and CDF of points; for continuous logarithmic distribution, number of points, value of points, and CDF of points.

[b] P = physical, B = behavioral, and M = metabolic parameter.

[c] NA = not applicable.

[d] NR = not required.

Table B-42 Base Values and Statistical Distributions of Input Parameters Used in the RESRAD-OFFSITE Code for the Offsite Resident via Water Transport Scenario (cont.)

Input screen title/parameter	Units	Type[b]	Base value for deterministic calculation	Source	Probabilistic analysis[a]					Description
					Distribution	Parameter 1	Parameter 2	Parameter 3	Parameter 4	
Distribution coefficients (cont.) To be input for all nuclides.										
Leafy vegetable fields	cm^3/g	P	See Table B-8	Same as above	None	NR	NR	NR	NR	Same as above
Pasture, silage growing areas	cm^3/g	P	See Table B-8	Same as above	None	NR	NR	NR	NR	Same as above
Livestock feed grain fields	cm^3/g	P	See Table B-8	Same as above	None	NR	NR	NR	NR	Same as above
Dwelling site	cm^3/g	P	See Table B-8	Same as above	None	NR	NR	NR	NR	Same as above
Deposition velocities To be input for all nuclides.										
Deposition velocity of respirable particulates	m/s	P	0.001*	For deterministic run base value is the code default and for probabilistic run distribution from Yu et. al. 2007 is used.	Log uniform	1E-6	1	NR	NR	The representative deposition velocity of respirable airborne particulates with which the nuclide shown in the form is associated.
Deposition velocity of all particulates	m/s	P	0.001*	For deterministic run base value is the code default and for probabilistic run distribution from Yu et. al. 2007 is used.	Log uniform	1E-6	1	NR	NR	The representative deposition velocity of all the airborne particulates with which the nuclide shown in the form is associated.
Transfer factors To be input for all nuclides.										

[a] For truncated lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution, parameter 3 = lower quantile, and parameter 4 = upper quantile; for lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution; for triangular distribution, parameter 1 = minimum, parameter 2 = mode or most likely, and parameter 3 = maximum; for truncated normal distribution, parameter 1 = mean, parameter 2 = standard deviation, parameter 3 = lower quantile, and parameter 4 = upper quantile; for bounded lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution, parameter 3 = minimum value, and parameter 4 = maximum value; for uniform distribution, , parameter 1 = minimum, and parameter 2 = maximum; for continuous linear distribution, number of points, value of points, and CDF of points; for continuous logarithmic distribution, number of points, value of points, and CDF of points.

[b] P = physical, B = behavioral, and M = metabolic parameter.

[c] NA = not applicable.

[d] NR = not required.

Table B-42 Base Values and Statistical Distributions of Input Parameters Used in the RESRAD-OFFSITE Code for the Offsite Resident via Water Transport Scenario (cont.)

Input screen title/parameter	Units	Type[b]	Base value for deterministic calculation	Source	Probabilistic analysis[a] Distribution	Parameter 1	Parameter 2	Parameter 3	Parameter 4	Description
Transfer factors To be input for all nuclides.										
Plant transfer factor for fruit, grain, non-leafy vegetables	(pCi/kg)/(pCi/kg)	P	See Table B-3	For deterministic run, median value from the parameter distribution is used as a base value. For probabilistic run, distributions from Yu et al., 2015 are used.	for all truncated lognormal-n	Table B-3	Table B-3	Table B-3	Table B-3	The ratio of radionuclide concentration in edible portions of the plant at harvest time to the dry soil radionuclide concentration. This Assumes that the same plant transfer factors can be used for leafy and non-leafy vegetables. The code has element specific values and the user is allowed to change these values.
Plant transfer factor for leafy vegetables	(pCi/kg)/(pCi/kg)	P	See Table B-3	Same as above	Same as above	Same as above	Same as above	Same as above	Same as above	Same as above
Plant transfer factor for pasture and silage	(pCi/kg)/(pCi/kg)	P	See Table B-3	Same as above	Same as above	Same as above	Same as above	Same as above	Same as above	Same as above
Plant transfer factor for livestock feed grain	(pCi/kg)/(pCi/kg)	P	See Table B-3	Same as above	Same as above	Same as above	Same as above	Same as above	Same as above	Same as above
Meat transfer factor	(pCi/kg)/(pCi/d)	P	See Table B-4	Same as above	for all truncated lognormal-n	Table B-4	Table B-4	Table B-4	Table B-4	The ratio of radionuclide concentration in beef to the daily intake of the same radionuclide in livestock feed or water. The code has element specific values and the user is allowed to change these values.
Milk transfer factor	(pCi/L)/(pCi/d)	P	See Table B-5	Same as above	for all truncated lognormal-n	Table B-5	Table B-5	Table B-5	Table B-5	The ratio of radionuclide concentration in milk to the daily intake of the same radionuclide in the livestock feed or water. The code has element specific values and the user is allowed to change these values.

[a] For truncated lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution, parameter 3 = lower quantile, and parameter 4 = upper quantile; for lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution; for triangular distribution, parameter 1 = minimum, parameter 2 = mode or most likely, and parameter 3 = maximum; for truncated normal distribution, parameter 1 = mean, parameter 2 = standard deviation, parameter 3 = lower quantile, and parameter 4 = upper quantile; for bounded lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution, parameter 3 = minimum value, and parameter 4 = maximum value; for uniform distribution, , parameter 1 = minimum, and parameter 2 = maximum; for continuous linear distribution, number of points, value of points, and CDF of points; for continuous logarithmic distribution, number of points, value of points, and CDF of points.

[b] P = physical, B = behavioral, and M = metabolic parameter.

[c] NA = not applicable.

[d] NR = not required.

Table B-42 Base Values and Statistical Distributions of Input Parameters Used in the RESRAD-OFFSITE Code for the Offsite Resident via Water Transport Scenario (cont.)

Input screen title/parameter	Units	Type[b]	Base value for deterministic calculation	Source	Probabilistic analysis[a] Distribution	Parameter 1	Parameter 2	Parameter 3	Parameter 4	Description
Transfer factors To be input for all nuclides.										
Plant transfer factor for leafy vegetables	(pCi/kg)/(pCi/kg)	P	See Table B-3	Same as above	Same as above	Same as above	Same as above	Same as above	Same as above	Same as above
Plant transfer factor for pasture and silage	(pCi/kg)/(pCi/kg)	P	See Table B-3	Same as above	Same as above	Same as above	Same as above	Same as above	Same as above	Same as above
Plant transfer factor for livestock feed grain	(pCi/kg)/(pCi/kg)	P	See Table B-3	Same as above	Same as above	Same as above	Same as above	Same as above	Same as above	Same as above
Meat transfer factor	(pCi/kg)/(pCi/d)	P	See Table B-4	Same as above	for all truncated lognormal-n	Table B-4	Table B-4	Table B-4	Table B-4	The ratio of radionuclide concentration in beef to the daily intake of the same radionuclide in livestock feed or water. The code has element specific values and the user is allowed to change these values.
Milk transfer factor	(pCi/L)/(pCi/d)	P	See Table B-5	Same as above	for all truncated lognormal-n	Table B-5	Table B-5	Table B-5	Table B-5	The ratio of radionuclide concentration in milk to the daily intake of the same radionuclide in the livestock feed or water. The code has element specific values and the user is allowed to change these values.
Fish bioaccumulation factor	(pCi/kg)/(pCi/L)	P	See Table B-6	Same as above	for all lognormal-n	Table B-6	Table B-6	Table B-6	Table B-6	The ratio of radionuclide concentration in the aquatic food to the concentration of the same radionuclide in water. The code has element specific aquatic bioaccumulation factors for fish and crustacea and mollusks and the user is allowed to change these values.

[a] For truncated lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution, parameter 3 = lower quantile, and parameter 4 = upper quantile; for lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution; for triangular distribution, parameter 1 = minimum, parameter 2 = mode or most likely, and parameter 3 = maximum; for truncated normal distribution, parameter 1 = mean, parameter 2 = standard deviation, parameter 3 = lower quantile, and parameter 4 = upper quantile; for bounded lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution, parameter 3 = minimum value, and parameter 4 = maximum value; for uniform distribution, , parameter 1 = minimum, and parameter 2 = maximum; for continuous linear distribution, number of points, value of points, and CDF of points; for continuous logarithmic distribution, number of points, value of points, and CDF of points.

[b] P = physical, B = behavioral, and M = metabolic parameter.

[c] NA = not applicable.

[d] NR = not required.

Table B-42 Base Values and Statistical Distributions of Input Parameters Used in the RESRAD-OFFSITE Code for the Offsite Resident via Water Transport Scenario (cont.)

Input screen title/parameter	Units	Type[b]	Base value for deterministic calculation	Source	Probabilistic analysis[a] Distribution	Parameter 1	Parameter 2	Parameter 3	Parameter 4	Description
Transfer factors (cont.) To be input for all nuclides.										
Crustacea bioaccumulation factor	(pCi/kg)/(pCi/L)	P	See Table B-7	For deterministic run, base values from Yu et al, 2015 are used.	None	NR	NR	NR	NR	The ratio of radionuclide concentration in the aquatic food to the concentration of the same radionuclide in water. The code has element specific aquatic bioaccumulation factors for fish and crustacea and mollusks and the user is allowed to change these values.
Reporting times										
Times at which output is reported	year	P	1, 3, 10, 30, 100, 300, 1000, 3000, 10000	Selected values	None	NR	NR	NR	NR	These are the times in years following the radiological survey for which tabular values for single-radionuclide soil guidelines and mixture sums are obtained. The code produces text reports at time zero and up to nine user-specified times. The times selected depend on the radionuclide analyzed. For short-lived radionuclides fewer reporting times are used.
Storage times The storage times used to calculate radioactive ingrowth and decay adjustment factors for food and feed due to storage. The code has values for fruit, non-leafy vegetables, and grain (one category), leafy vegetables, pasture and silage, milk, well and surface water, livestock feed grain, meat, fish, and crustacea and mollusks.										
Storage time for surface water	d	B	1	Code default	None	NR	NR	NR	NR	
Storage time for well water	d	B	1	Code default	None	NR	NR	NR	NR	
Storage time for fruits, grain, and non-leafy vegetables	d	B	14	Code default	None	NR	NR	NR	NR	
Storage time for leafy vegetables	d	B	1	Code default	None	NR	NR	NR	NR	
Storage time for pasture and silage	d	B	1	Code default	None	NR	NR	NR	NR	
Storage time for livestock feed grain	d	B	45	Code default	None	NR	NR	NR	NR	

[a] For truncated lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution, parameter 3 = lower quantile, and parameter 4 = upper quantile; for lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution; for triangular distribution, parameter 1 = minimum, parameter 2 = mode or most likely, and parameter 3 = maximum; for truncated normal distribution, parameter 1 = mean, parameter 2 = standard deviation, parameter 3 = lower quantile, and parameter 4 = upper quantile; for bounded lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution, parameter 3 = minimum value, and parameter 4 = maximum value; for uniform distribution, , parameter 1 = minimum, and parameter 2 = maximum; for continuous linear distribution, number of points, value of points, and CDF of points; for continuous logarithmic distribution, number of points, value of points, and CDF of points.
[b] P = physical, B = behavioral, and M = metabolic parameter.
[c] NA = not applicable.
[d] NR = not required.

Table B-42 Base Values and Statistical Distributions of Input Parameters Used in the RESRAD-OFFSITE Code for the Offsite Resident via Water Transport Scenario (cont.)

Input screen title/parameter	Units	Type[b]	Base value for deterministic calculation	Source	Probabilistic analysis[a]					Description
					Distribution	Parameter 1	Parameter 2	Parameter 3	Parameter 4	
Storage times The storage times used to calculate radioactive ingrowth and decay adjustment factors for food and feed due to storage. The code has values for fruit, non-leafy vegetables, and grain (one category), leafy vegetables, pasture and silage, milk, well and surface water, livestock feed grain, meat, fish, and crustacea and mollusks.										
Storage time for surface water	d	B	1	Code default	None	NR	NR	NR	NR	
Storage time for well water	d	B	1	Code default	None	NR	NR	NR	NR	
Storage time for fruits, grain, and non-leafy vegetables	d	B	14	Code default	None	NR	NR	NR	NR	
Storage time for leafy vegetables	d	B	1	Code default	None	NR	NR	NR	NR	
Storage time for pasture and silage	d	B	1	Code default	None	NR	NR	NR	NR	
Storage time for livestock feed grain	d	B	45	Code default	None	NR	NR	NR	NR	
Storage time for meat	d	B	20	Code default	None	NR	NR	NR	NR	
Storage time for milk	d	B	1	Code default	None	NR	NR	NR	NR	
Storage time for fish	d	B	7	Code default	None	NR	NR	NR	NR	
Storage time for crustacea and mollusks	d	B	7	Code default	None	NR	NR	NR	NR	
Site layout										
Bearing of X axis (clockwise angle from North)	degree	P	90	Site specific	None	NR	NR	NR	NR	
X dimension of primary contamination	m	P	100	Site specific	None	NR	NR	NR	NR	The primary contamination modeled as a rectangle for atmospheric transport calculations. The lengths of the sides on the rectangle, the X and Y dimension, are used to define rectangular region for atmospheric transport calculations.

[a] For truncated lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution, parameter 3 = lower quantile, and parameter 4 = upper quantile; for lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution; for triangular distribution, parameter 1 = minimum, parameter 2 = mode or most likely, and parameter 3 = maximum; for truncated normal distribution, parameter 1 = mean, parameter 2 = standard deviation, parameter 3 = lower quantile, and parameter 4 = upper quantile; for bounded lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution, parameter 3 = minimum value, and parameter 4 = maximum value; for uniform distribution, , parameter 1 = minimum, and parameter 2 = maximum; for continuous linear distribution, number of points, value of points, and CDF of points; for continuous logarithmic distribution, number of points, value of points, and CDF of points.

[b] P = physical, B = behavioral, and M = metabolic parameter.

[c] NA = not applicable.

[d] NR = not required.

Table B-42 Base Values and Statistical Distributions of Input Parameters Used in the RESRAD-OFFSITE Code for the Offsite Resident via Water Transport Scenario (cont.)

Input screen title/parameter	Units	Type[b]	Base value for deterministic calculation	Source	Probabilistic analysis[a] Distribution	Parameter 1	Parameter 2	Parameter 3	Parameter 4	Description
Storage times The storage times used to calculate radioactive ingrowth and decay adjustment factors for food and feed due to storage. The code has values for fruit, non-leafy vegetables, and grain (one category), leafy vegetables, pasture and silage, milk, well and surface water, livestock feed grain, meat, fish, and crustacea and mollusks.										
Storage time for surface water	d	B	1	Code default	None	NR	NR	NR	NR	
Storage time for well water	d	B	1	Code default	None	NR	NR	NR	NR	
Storage time for fruits, grain, and non-leafy vegetables	d	B	14	Code default	None	NR	NR	NR	NR	
Storage time for leafy vegetables	d	B	1	Code default	None	NR	NR	NR	NR	
Storage time for pasture and silage	d	B	1	Code default	None	NR	NR	NR	NR	
Storage time for livestock feed grain	d	B	45	Code default	None	NR	NR	NR	NR	
Storage time for meat	d	B	20	Code default	None	NR	NR	NR	NR	
Storage time for milk	d	B	1	Code default	None	NR	NR	NR	NR	
Storage time for fish	d	B	7	Code default	None	NR	NR	NR	NR	
Storage time for crustacea and mollusks	d	B	7	Code default	None	NR	NR	NR	NR	
Site layout										
Bearing of X axis (clockwise angle from North)	degree	P	90	Site specific	None	NR	NR	NR	NR	
X dimension of primary contamination	m	P	100	Site specific	None	NR	NR	NR	NR	The primary contamination modeled as a rectangle for atmospheric transport calculations. The lengths of the sides on the rectangle, the X and Y dimension, are used to define rectangular region for atmospheric transport calculations.
Y dimension of primary contamination	m	P	100	Site specific	None	NR	NR	NR	NR	

[a] For truncated lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution, parameter 3 = lower quantile, and parameter 4 = upper quantile; for lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution; for triangular distribution, parameter 1 = minimum, parameter 2 = mode or most likely, and parameter 3 = maximum; for truncated normal distribution, parameter 1 = mean, parameter 2 = standard deviation, parameter 3 = lower quantile, and parameter 4 = upper quantile; for bounded lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution, parameter 3 = minimum value, and parameter 4 = maximum value; for uniform distribution, , parameter 1 = minimum, and parameter 2 = maximum; for continuous linear distribution, number of points, value of points, and CDF of points; for continuous logarithmic distribution, number of points, value of points, and CDF of points.

[b] P = physical, B = behavioral, and M = metabolic parameter.

[c] NA = not applicable.

[d] NR = not required.

Table B-42 Base Values and Statistical Distributions of Input Parameters Used in the RESRAD-OFFSITE Code for the Offsite Resident via Water Transport Scenario (cont.)

Input screen title/parameter	Units	Type[b]	Base value for deterministic calculation	Source	Probabilistic analysis[a]					Description
					Distribution	Parameter 1	Parameter 2	Parameter 3	Parameter 4	
Site layout (cont.)										
Smaller X coordinate of the fruit, grain, non-leafy vegetables plot	m	P	34.375	Site specific	None	NR	NR	NR	NR	The fruit, grain and non-leafy vegetable, the leafy vegetable, the pasture and silage, the livestock-feed grain growing areas and dwelling site all approximated by rectangular shapes. The sides of these rectangles must be parallel to the sides of the primary contamination. The location and size of these rectangles are specified by the Cartesian coordinates of two opposite corners.
Larger X coordinate of the fruit, grain, non-leafy vegetables plot	m	P	65.625	Site specific	None	NR	NR	NR	NR	See above
Smaller Y coordinate of the fruit, grain, non-leafy vegetables plot	m	P	234	Site specific	None	NR	NR	NR	NR	See above
Larger Y coordinate of the fruit, grain, non-leafy vegetables plot	m	P	266	Site specific	None	NR	NR	NR	NR	See above
Smaller X coordinate of the leafy vegetables plot	m	P	34.375	Site specific	None	NR	NR	NR	NR	See above
Larger X coordinate of the leafy vegetables plot	m	P	65.625	Site specific	None	NR	NR	NR	NR	See above
Smaller Y coordinate of the leafy vegetables plot	m	P	268	Site specific	None	NR	NR	NR	NR	See above
Larger Y coordinate of the leafy vegetables plot	m	P	300	Site specific	None	NR	NR	NR	NR	See above
Smaller X coordinate of the pasture, silage growing area	m	P	0	Site specific	None	NR	NR	NR	NR	See above

[a] For truncated lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution, parameter 3 = lower quantile, and parameter 4 = upper quantile; for lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution; for triangular distribution, parameter 1 = minimum, parameter 2 = mode or most likely, and parameter 3 = maximum; for truncated normal distribution, parameter 1 = mean, parameter 2 = standard deviation, parameter 3 = lower quantile, and parameter 4 = upper quantile; for bounded lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution, parameter 3 = minimum value, and parameter 4 = maximum value; for uniform distribution, , parameter 1 = minimum, and parameter 2 = maximum; for continuous linear distribution, number of points, value of points, and CDF of points; for continuous logarithmic distribution, number of points, value of points, and CDF of points.

[b] P = physical, B = behavioral, and M = metabolic parameter.

[c] NA = not applicable.

[d] NR = not required.

Table B-42 Base Values and Statistical Distributions of Input Parameters Used in the RESRAD-OFFSITE Code for the Offsite Resident via Water Transport Scenario (cont.)

Input screen title/parameter	Units	Type[b]	Base value for deterministic calculation	Source	Probabilistic analysis[a]					Description
					Distribution	Parameter 1	Parameter 2	Parameter 3	Parameter 4	
Site layout (cont.)										
Larger X coordinate of the pasture, silage growing area	m	P	100	Site specific	None	NR	NR	NR	NR	See above
Smaller Y coordinate of the pasture, silage growing area	m	P	450	Site specific	None	NR	NR	NR	NR	See above
Larger Y coordinate of the pasture, silage growing area	m	P	550	Site specific	None	NR	NR	NR	NR	See above
Smaller X coordinate of the grain fields	m	P	0	Site specific	None	NR	NR	NR	NR	See above
Larger X coordinate of the grain fields	m	P	100	Site specific	None	NR	NR	NR	NR	See above
Smaller Y coordinate of the grain fields	m	P	300	Site specific	None	NR	NR	NR	NR	See above
Larger Y coordinate of the grain fields	m	P	400	Site specific	None	NR	NR	NR	NR	See above
Smaller X coordinate of the dwelling site	m	P	34.375	Site specific	None	NR	NR	NR	NR	See above
Larger X coordinate of the dwelling site	m	P	65.625	Site specific	None	NR	NR	NR	NR	See above
Smaller Y coordinate of the dwelling site	m	P	134	Site specific	None	NR	NR	NR	NR	See above
Larger Y coordinate of the dwelling site	m	P	166	Site specific	None	NR	NR	NR	NR	See above
Smaller X coordinate of the surface-water body	m	P	-100	Site specific	None	NR	NR	NR	NR	The surface water body approximated by rectangular shape in the atmospheric transport model. The sides of the rectangle are parallel to the sides of primary contamination.
Larger X coordinate of the surface-water body	m	P	200	Site specific	None	NR	NR	NR	NR	See above
Smaller Y coordinate of the surface-water body	m	P	550	Site specific	None	NR	NR	NR	NR	See above

[a] For truncated lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution, parameter 3 = lower quantile, and parameter 4 = upper quantile; for lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution; for triangular distribution, parameter 1 = minimum, parameter 2 = mode or most likely, and parameter 3 = maximum; for truncated normal distribution, parameter 1 = mean, parameter 2 = standard deviation, parameter 3 = lower quantile, and parameter 4 = upper quantile; for bounded lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution, parameter 3 = minimum value, and parameter 4 = maximum value; for uniform distribution, , parameter 1 = minimum, and parameter 2 = maximum; for continuous linear distribution, number of points, value of points, and CDF of points; for continuous logarithmic distribution, number of points, value of points, and CDF of points.

[b] P = physical, B = behavioral, and M = metabolic parameter.

[c] NA = not applicable.

[d] NR = not required.

Table B-42 Base Values and Statistical Distributions of Input Parameters Used in the RESRAD-OFFSITE Code for the Offsite Resident via Water Transport Scenario (cont.)

Input screen title/parameter	Units	Type[b]	Base value for deterministic calculation	Source	Probabilistic analysis[a]					Description
					Distribution	Parameter 1	Parameter 2	Parameter 3	Parameter 4	
Site layout (cont.)										
Larger Y coordinate of the surface-water body	m	P	850	Site specific	None	NR	NR	NR	NR	See above
Physical and hydrological										
Precipitation	m/yr	P	0.5	Code default	None	NR	NR	NR	NR	The average volume of water in the form of rain, snow, hail, or sleet that falls per unit of area per unit of time at the site. It is used in a number of calculations including 1) radionuclide leaching from the contaminated zone, and 2) accumulation of contaminants in the agricultural fields and pastures. Site-specific data should be used.
Wind speed	m/s	P	.89	Code default	None	NR	NR	NR	NR	The overall average of the wind speed, measured near the ground, in a one-year period. Used to compute the onsite contaminant concentration in airborne dust and the atmospheric release rate.
Primary contaminatio										
Area of primary contamination	m^2	P	10,000	Code default	None	NR	NR	NR	NR	Total area of the site homogeneously contaminated.
Length of contamination parallel to aquifer flow	m	P	100	Code default	None	NR	NR	NR	NR	The distance between two parallel lines perpendicular to the direction of aquifer flow, one at the upgradient edge of the contaminated zone and the other at the downgradient edge of the contaminated zone.

[a] For truncated lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution, parameter 3 = lower quantile, and parameter 4 = upper quantile; for lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution; for triangular distribution, parameter 1 = minimum, parameter 2 = mode or most likely, and parameter 3 = maximum; for truncated normal distribution, parameter 1 = mean, parameter 2 = standard deviation, parameter 3 = lower quantile, and parameter 4 = upper quantile; for bounded lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution, parameter 3 = minimum value, and parameter 4 = maximum value; for uniform distribution, , parameter 1 = minimum, and parameter 2 = maximum; for continuous linear distribution, number of points, value of points, and CDF of points; for continuous logarithmic distribution, number of points, value of points, and CDF of points.

[b] P = physical, B = behavioral, and M = metabolic parameter.

[c] NA = not applicable.

[d] NR = not required.

Table B-42 Base Values and Statistical Distributions of Input Parameters Used in the RESRAD-OFFSITE Code for the Offsite Resident via Water Transport Scenario (cont.)

Input screen title/parameter	Units	Type[b]	Base value for deterministic calculation	Source	Probabilistic analysis[a]					Description
					Distribution	Parameter 1	Parameter 2	Parameter 3	Parameter 4	
Primary contamination (cont.)										
Depth of soil mixing layer	m	P, B	0.15	For deterministic run, base value selected is the median from the distribution. For probabilistic run, distribution from NUREG/ CR-6697 is used.	Triangular	0	0.15	0.6		The thickness of surface soil that may be assumed to be mixed uniformly from time to time due to anthropogenic or physical processes. Used in calculating the depth factor for the onsite components of dust inhalation and soil ingestion pathways and for computing the release to the atmosphere. The depth factor is the fraction of resuspendable soil particles at the ground surface that are contaminated. Calculated by assuming that mixing of the soil will occur within a layer of thickness (depth of mixing layer) at the surface.
Mass loading of all particulates	g/m^3	B	0.0001	For deterministic run, base value selected is the code default. For probabilistic run, distribution from Yu et al. 2007 is used.	Truncated lognormal-N	-10.02	0.455	0.001	0.999	The air/soil concentration ratio or the average mass of all particulates in a unit volume of air, above the primary contamination or above the offsite location. Used to compute the rate of release of all particulates from the primary contamination or from each of the offsite locations.

[a] For truncated lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution, parameter 3 = lower quantile, and parameter 4 = upper quantile; for lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution; for triangular distribution, parameter 1 = minimum, parameter 2 = mode or most likely, and parameter 3 = maximum; for truncated normal distribution, parameter 1 = mean, parameter 2 = standard deviation, parameter 3 = lower quantile, and parameter 4 = upper quantile; for bounded lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution, parameter 3 = minimum value, and parameter 4 = maximum value; for uniform distribution, , parameter 1 = minimum, and parameter 2 = maximum; for continuous linear distribution, number of points, value of points, and CDF of points; for continuous logarithmic distribution, number of points, value of points, and CDF of points.

[b] P = physical, B = behavioral, and M = metabolic parameter.

[c] NA = not applicable.

[d] NR = not required.

Table B-42 Base Values and Statistical Distributions of Input Parameters Used in the RESRAD-OFFSITE Code for the Offsite Resident via Water Transport Scenario (cont.)

Input screen title/parameter	Units	Type[b]	Base value for deterministic calculation	Source	Probabilistic analysis[a] Distribution	Parameter 1	Parameter 2	Parameter 3	Parameter 4	Description
Primary contamination (cont.)										
Deposition velocity of all particulates	m/s	P	0.001	For deterministic run, base value selected is the code default. For probabilistic run, distribution from Yu et al. 2007 is used.	Loguniform	1E-6	1			The average velocity of all particulates with which dust settles onto the contaminated zone. Used to calculate the release to the atmosphere. Required for all radionuclides.
Respirable particulates as a fraction of total particulates	—	P	1	Code default	NA	NA	NA	NA	NA	Fraction of respirable particulates.
Deposition velocity of respirable particulates	m/s	P	0.001	For deterministic run, base value selected is the code default. For probabilistic run, distribution from Yu et al. 2007 is used.	Loguniform	1E-6	1			The average velocity of respirable particulates with which dust settles onto the contaminated zone. It is used to calculate the release to the atmosphere.Required for all radionuclides.

[a] For truncated lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution, parameter 3 = lower quantile, and parameter 4 = upper quantile; for lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution; for triangular distribution, parameter 1 = minimum, parameter 2 = mode or most likely, and parameter 3 = maximum; for truncated normal distribution, parameter 1 = mean, parameter 2 = standard deviation, parameter 3 = lower quantile, and parameter 4 = upper quantile; for bounded lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution, parameter 3 = minimum value, and parameter 4 = maximum value; for uniform distribution, , parameter 1 = minimum, and parameter 2 = maximum; for continuous linear distribution, number of points, value of points, and CDF of points; for continuous logarithmic distribution, number of points, value of points, and CDF of points.

[b] P = physical, B = behavioral, and M = metabolic parameter.

[c] NA = not applicable.

[d] NR = not required.

Table B-42 Base Values and Statistical Distributions of Input Parameters Used in the RESRAD-OFFSITE Code for the Offsite Resident via Water Transport Scenario (cont.)

Input screen title/parameter	Units	Type[b]	Base value for deterministic calculation	Source	Probabilistic analysis[a] Distribution	Parameter 1	Parameter 2	Parameter 3	Parameter 4	Description
Primary contamination (cont.)										
Irrigation applied per year	m/yr	B	0.2	For deterministic run, the base value selected is the code default. For probabilistic run, the minimum being 1/2 of the base value, and the maximum being two times the base value.	Uniform	0.1	0.4			The average annual irrigation rate, in meters/year, applied to the region of primary contamination. It is the amount of irrigation water applied over a period of one year, and is not the actual rate of irrigation applied during the growing period. It is one of the parameters used to calculate radionuclide leaching from the contaminated zone. Site-specific data should be used.
Evapotranspiration coefficient	—	P	0.5	For deterministic run, base value selected is the code default. For probabilistic run, the minimum value is 50 percent lower than the base value and the maximum value is 50 percent higher than the base value.	Uniform	0.25	0.75			The fraction of precipitation and irrigation water that penetrates the topsoil lost to the atmosphere by evaporation and by transpiration by the vegetation. The evapotranspiration coefficient is one of a number of parameters used to calculate radionuclide leaching from the contaminated zone.

[a] For truncated lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution, parameter 3 = lower quantile, and parameter 4 = upper quantile; for lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution; for triangular distribution, parameter 1 = minimum, parameter 2 = mode or most likely, and parameter 3 = maximum; for truncated normal distribution, parameter 1 = mean, parameter 2 = standard deviation, parameter 3 = lower quantile, and parameter 4 = upper quantile; for bounded lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution, parameter 3 = minimum value, and parameter 4 = maximum value; for uniform distribution, , parameter 1 = minimum, and parameter 2 = maximum; for continuous linear distribution, number of points, value of points, and CDF of points; for continuous logarithmic distribution, number of points, value of points, and CDF of points.

[b] P = physical, B = behavioral, and M = metabolic parameter.

[c] NA = not applicable.

[d] NR = not required.

Table B-42 Base Values and Statistical Distributions of Input Parameters Used in the RESRAD-OFFSITE Code for the Offsite Resident via Water Transport Scenario (cont.)

Input screen title/parameter	Units	Type[b]	Base value for deterministic calculation	Source	Probabilistic analysis[a] Distribution	Parameter 1	Parameter 2	Parameter 3	Parameter 4	Description
Primary contamination (cont.)										
Runoff coefficient	—	P	0.2	For deterministic run, base value selected is the code default. For probabilistic, run distribution from NUREG/ CR-6697	Uniform	0.1	0.8			The fraction of the average annual precipitation that does not penetrate the top soil, but leaves the area of concern as surface runoff. The runoff coefficient is one of a number of parameters used to calculate radionuclide leaching from the contaminated zone.
Rainfall and runoff factor	—	P	160	For deterministic run, base value selected is the code default. For probabilistic run, distribution from Yu et al. 2007 is used.	Continuous linear					Known as the rainfall erosivity factor, it is a measure of the energy of the rainfall. The value entered is used to compute the erosion rate at all locations.
Slope-length, steepness factor	—	P	.4	For deterministic run, base value selected is the code default. For probabilistic run, distribution from Yu et al. 2007 is used.	Continuous linear					This factor accounts for the effect of the profile of the terrain (the slope of the land and the length of the slope) on the erosion rate.

[a] For truncated lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution, parameter 3 = lower quantile, and parameter 4 = upper quantile; for lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution; for triangular distribution, parameter 1 = minimum, parameter 2 = mode or most likely, and parameter 3 = maximum; for truncated normal distribution, parameter 1 = mean, parameter 2 = standard deviation, parameter 3 = lower quantile, and parameter 4 = upper quantile; for bounded lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution, parameter 3 = minimum value, and parameter 4 = maximum value; for uniform distribution, , parameter 1 = minimum, and parameter 2 = maximum; for continuous linear distribution, number of points, value of points, and CDF of points; for continuous logarithmic distribution, number of points, value of points, and CDF of points.

[b] P = physical, B = behavioral, and M = metabolic parameter.

[c] NA = not applicable.

[d] NR = not required.

Table B-42 Base Values and Statistical Distributions of Input Parameters Used in the RESRAD-OFFSITE Code for the Offsite Resident via Water Transport Scenario (cont.)

Input screen title/parameter	Units	Type[b]	Base value for deterministic calculation	Source	Probabilistic analysis[a]					Description
					Distribution	Parameter 1	Parameter 2	Parameter 3	Parameter 4	
Primary contamination (cont.)										
Cover and management factor	–	B, P	0.003	For deterministic run, base value selected is the code default. For probabilistic run, distribution from Yu et al. 2007 is used.	Continuous linear					This factor accounts for the effects of vegetation, mulching, etc., on the erosion rate.
Support practice factor	—	B, P	1	For deterministic run, base value selected is the code default. For probabilistic run, distribution from Yu et al. 2007 is used.	Continuous linear					This factor accounts for conservation practices aimed at reducing erosion.
Fraction of primary contamination submerged	—	P	0	Site specific – no distribution						Part of the primary contamination below the water table.

[a] For truncated lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution, parameter 3 = lower quantile, and parameter 4 = upper quantile; for lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution; for triangular distribution, parameter 1 = minimum, parameter 2 = mode or most likely, and parameter 3 = maximum; for truncated normal distribution, parameter 1 = mean, parameter 2 = standard deviation, parameter 3 = lower quantile, and parameter 4 = upper quantile; for bounded lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution, parameter 3 = minimum value, and parameter 4 = maximum value; for uniform distribution, , parameter 1 = minimum, and parameter 2 = maximum; for continuous linear distribution, number of points, value of points, and CDF of points; for continuous logarithmic distribution, number of points, value of points, and CDF of points.

[b] P = physical, B = behavioral, and M = metabolic parameter.

[c] NA = not applicable.

[d] NR = not required.

Table B-42 Base Values and Statistical Distributions of Input Parameters Used in the RESRAD-OFFSITE Code for the Offsite Resident via Water Transport Scenario (cont.)

Input screen title/parameter	Units	Type[b]	Base value for deterministic calculation	Source	Probabilistic analysis[a] Distribution	Parameter 1	Parameter 2	Parameter 3	Parameter 4	Description
Contaminated zone										
Thickness of contaminated zone above water table	m	P	2	For deterministic run, base value selected is the code default. For probabilistic run, the minimum value is 50 percent lower than the base value and the maximum value is 50 percent higher than the base value.	Uniform	1	3			The distance between the uppermost and lowermost soil samples with radionuclide concentrations clearly above background.
Total porosity of contaminated zone	—	P	0.425	For deterministic run, base value selected is the mean from the distribution. For probabilistic run, distribution from NUREG/CR-6697 is used.	Truncated normal	0.425	.0867	0.001	0.999	The ratio of the pore volume to the total volume of the contaminated zone.
Erosion rate of contaminated zone	—	NA	1.132E-5 (calculated)	Calculated	NA	NA	NA	NA	NA	Calculated from many uncertain parameters including soil erodibility factor

[a] For truncated lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution, parameter 3 = lower quantile, and parameter 4 = upper quantile; for lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution; for triangular distribution, parameter 1 = minimum, parameter 2 = mode or most likely, and parameter 3 = maximum; for truncated normal distribution, parameter 1 = mean, parameter 2 = standard deviation, parameter 3 = lower quantile, and parameter 4 = upper quantile; for bounded lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution, parameter 3 = minimum value, and parameter 4 = maximum value; for uniform distribution, , parameter 1 = minimum, and parameter 2 = maximum; for continuous linear distribution, number of points, value of points, and CDF of points; for continuous logarithmic distribution, number of points, value of points, and CDF of points.

[b] P = physical, B = behavioral, and M = metabolic parameter.

[c] NA = not applicable.

[d] NR = not required.

Table B-42 Base Values and Statistical Distributions of Input Parameters Used in the RESRAD-OFFSITE Code for the Offsite Resident via Water Transport Scenario (cont.)

Input screen title/parameter	Units	Type[b]	Base value for deterministic calculation	Source	Probabilistic analysis[a]					Description
					Distribution	Parameter 1	Parameter 2	Parameter 3	Parameter 4	
Contaminated zone (cont.)										
Dry bulk density of contaminated zone	g/cm^3	P	1.52	For deterministic run, base value selected is the mean from the distribution. For probabilistic run, distribution from NUREG/CR-6697 is used.	Truncated normal	1.52	0.23	0.001	0.999	Bulk density of the contaminated zone.
Soil erodibility factor of contaminated zone	tons/acre	P	0.4	For deterministic run, base value selected is the code default. For probabilistic run, distribution from Yu et al. 2007 is used.	Continuous linear	None	NR	NR	NR	This quantifies the susceptibility of the soil to erosion.
Effective porosity	—	P	0.355	For deterministic run, base value selected is the mean from the distribution. For probabilistic run, distribution from NUREG/CR-6697 is used.	Truncated normal	0.355	0.0906	0.001	0.999	The volume fraction of soil through which water flows. Part of the soil moisture may not contribute to the movement of contaminants. Thus the effective porosity will be less than or equal to the total porosity.

[a] For truncated lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution, parameter 3 = lower quantile, and parameter 4 = upper quantile; for lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution; for triangular distribution, parameter 1 = minimum, parameter 2 = mode or most likely, and parameter 3 = maximum; for truncated normal distribution, parameter 1 = mean, parameter 2 = standard deviation, parameter 3 = lower quantile, and parameter 4 = upper quantile; for bounded lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution, parameter 3 = minimum value, and parameter 4 = maximum value; for uniform distribution, , parameter 1 = minimum, and parameter 2 = maximum; for continuous linear distribution, number of points, value of points, and CDF of points; for continuous logarithmic distribution, number of points, value of points, and CDF of points.

[b] P = physical, B = behavioral, and M = metabolic parameter.

[c] NA = not applicable.

[d] NR = not required.

Table B-42 Base Values and Statistical Distributions of Input Parameters Used in the RESRAD-OFFSITE Code for the Offsite Resident via Water Transport Scenario (cont.)

Input screen title/parameter	Units	Type[b]	Base value for deterministic calculation	Source	Probabilistic analysis[a] Distribution	Parameter 1	Parameter 2	Parameter 3	Parameter 4	Description
Contaminated zone (cont.)										
Field capacity of contaminated zone	—	P	0.3	Code default	None	NR	NR	NR	NR	The volumetric moisture content of soil at which (free) gravity drainage ceases. The amount of moisture retained in a column of soil against the force of gravity. The field capacity is one of several hydrogeological parameters used to calculate water transport through the unsaturated part of the soil.
Soil b parameter of contaminated zone	—	P	5.3	For deterministic run, base value selected is the code default. For probabilistic run, distribution from NUREG/CR-6697 is used.	Bounded lognormal-N	1.06	0.66	0.5	30	It is an empirical and dimensionless parameter used to evaluate the saturation ratio (or the volumetric water saturation) of the soil according to a soil characteristic function called the conductivity function.
Hydraulic conductivity of contaminated zone	m/yr	P	10	For deterministic run, base value selected is the code default.	None	NR	NR	NR	NR	The measure of the soil's ability to transmit water when subjected to a hydraulic gradient. The hydraulic conductivity depends on the soil grain size, the structure of the soil matrix, the type of soil fluid, and the relative amount of soil fluid (saturation) present in the soil matrix.

[a] For truncated lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution, parameter 3 = lower quantile, and parameter 4 = upper quantile; for lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution; for triangular distribution, parameter 1 = minimum, parameter 2 = mode or most likely, and parameter 3 = maximum; for truncated normal distribution, parameter 1 = mean, parameter 2 = standard deviation, parameter 3 = lower quantile, and parameter 4 = upper quantile; for bounded lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution, parameter 3 = minimum value, and parameter 4 = maximum value; for uniform distribution, , parameter 1 = minimum, and parameter 2 = maximum; for continuous linear distribution, number of points, value of points, and CDF of points; for continuous logarithmic distribution, number of points, value of points, and CDF of points.

[b] P = physical, B = behavioral, and M = metabolic parameter.

[c] NA = not applicable.

[d] NR = not required.

Table B-42 Base Values and Statistical Distributions of Input Parameters Used in the RESRAD-OFFSITE Code for the Offsite Resident via Water Transport Scenario (cont.)

Input screen title/parameter	Units	Type[b]	Base value for deterministic calculation	Source	Probabilistic analysis[a] Distribution	Parameter 1	Parameter 2	Parameter 3	Parameter 4	Description
Contaminated zone (cont.)										
Longitudinal dispersivity	m	P	0.05	For deterministic run, base value selected is the code default. For probabilistic run, uniform between half and double of the default value.	Uniform	0.025	0.1	None	NR	The ratio between the longitudinal dispersion coefficient and pore water velocity (see Section 2.2 of Appendix B of NUREG/CR-7127).
Depth of top of primary contamination below water table	m	P	0	Code default	None	NR	NR	NR	NR	Calculated
Clean cover										
Thickness of clean cover	m	P	0.15	Clean cover of thickness 0.15 m is assumed	Triangular	0.0	0.3	NR	NR	Distance from the ground surface to the contaminated zone.
Total porosity of clean cover	—	P	NR	NR	NR	NR	NR	NR	NR	The volume fraction of soil occupied by liquid and gaseous phases. The total porosity is one of several hydrogeological parameters used to calculate water transport times.
Erosion rate of clean cover	m/yr	NA	1.132E-5 (calculated)							Calculated from many uncertain parameters including soil erodibility factor

[a] For truncated lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution, parameter 3 = lower quantile, and parameter 4 = upper quantile; for lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution; for triangular distribution, parameter 1 = minimum, parameter 2 = mode or most likely, and parameter 3 = maximum; for truncated normal distribution, parameter 1 = mean, parameter 2 = standard deviation, parameter 3 = lower quantile, and parameter 4 = upper quantile; for bounded lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution, parameter 3 = minimum value, and parameter 4 = maximum value; for uniform distribution, , parameter 1 = minimum, and parameter 2 = maximum; for continuous linear distribution, number of points, value of points, and CDF of points; for continuous logarithmic distribution, number of points, value of points, and CDF of points.

[b] P = physical, B = behavioral, and M = metabolic parameter.

[c] NA = not applicable.

[d] NR = not required.

Table B-42 Base Values and Statistical Distributions of Input Parameters Used in the RESRAD-OFFSITE Code for the Offsite Resident via Water Transport Scenario (cont.)

Input screen title/parameter	Units	Type[b]	Base value for deterministic calculation	Source	Probabilistic analysis[a]					Description
					Distribution	Parameter 1	Parameter 2	Parameter 3	Parameter 4	
Clean cove (cont.)r										
Dry bulk density of clean cover	g/cm^3	P	1.52	For deterministic run, the value selected is the mean from the distribution. For probabilistic run, distribution from NUREG/CR-6697 is used.	Truncated normal	1.52	0.23	0.001	0.999	Bulk density of the cover material.
Soil erodibility factor of clean cover	tons/acre	P	0.4	For deterministic run, the value selected is the code default. For probabilistic run, distribution from Yu et al. 2007 is used.	Continuous linear					See contaminated zone soil erodibility factor parameter.
Volumetric water content of clean cover	—	P	NR	NR	NR	NR	NR	NR	NR	It is the volumetric water content in a porous medium that represents the fraction of the total volume of porous medium occupied by the water. The value should be less than the total porosity of the medium.
Fate of Material Eroded from the Primary Contamination by Runoff										
Fraction of eroded radionuclides deposited at dwelling site	—	P	0	Assumption	NR	NR	NR	NR	NR	The fraction of the contaminated soil eroded from the area of primary contamination that reaches the dwelling site.

[a] For truncated lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution, parameter 3 = lower quantile, and parameter 4 = upper quantile; for lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution; for triangular distribution, parameter 1 = minimum, parameter 2 = mode or most likely, and parameter 3 = maximum; for truncated normal distribution, parameter 1 = mean, parameter 2 = standard deviation, parameter 3 = lower quantile, and parameter 4 = upper quantile; for bounded lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution, parameter 3 = minimum value, and parameter 4 = maximum value; for uniform distribution, , parameter 1 = minimum, and parameter 2 = maximum; for continuous linear distribution, number of points, value of points, and CDF of points; for continuous logarithmic distribution, number of points, value of points, and CDF of points.

[b] P = physical, B = behavioral, and M = metabolic parameter.

[c] NA = not applicable.

[d] NR = not required.

Table B-42 Base Values and Statistical Distributions of Input Parameters Used in the RESRAD-OFFSITE Code for the Offsite Resident via Water Transport Scenario (cont.)

Input screen title/parameter	Units	Type[b]	Base value for deterministic calculation	Source	Probabilistic analysis[a]					Description
					Distribution	Parameter 1	Parameter 2	Parameter 3	Parameter 4	
Fate of Material Eroded from the Primary Contamination by Runoff (cont.)										
Fraction of eroded radionuclides deposited in the non-leafy vegetable plot	—	P	0	Assumption	NR	NR	NR	NR	NR	The fraction of the contaminated soil eroded from the area of primary contamination that reaches the nonleafy vegetable plot.
Fraction of eroded radionuclides deposited in the leafy vegetable plot	—	P	0	Assumption	NR	NR	NR	NR	NR	The fraction of the contaminated soil eroded from the area of primary contamination that reaches the leafy vegetable plot.
Fraction of eroded radionuclides deposited in the pasture plot	—	P	0	Assumption	NR	NR	NR	NR	NR	The fraction of the contaminated soil eroded from the area of primary contamination that reaches the pasture plot.
Fraction of eroded radionuclides deposited in the feed grain plot	—	P	0	Assumption	NR	NR	NR	NR	NR	The fraction of the contaminated soil eroded from the area of primary contamination that reaches the feed grain plot.
Fraction of eroded radionuclides deposited in the surface water body	—	P	1	Assumption	NR	NR	NR	NR	NR	The fraction of the contaminated soil eroded from the area of primary contamination that reaches the surface water body.
Agricultural Areas										
Fruit, grain, non-leafy										For description of parameters see description in contaminated zone and cover parameters.
Area of fruit, grain, and non-leafy vegetable plot	m^2	P	1000 (calculated from parameters in Site Layout Form)	Assumption	NR	NR	NR	NR	NR	Area for growing fruit, grain, and non-leafy vegetables.
Fraction of area of fruit, grain, and non-leafy vegetable plot directly over primary contamination	—	P	0	Assumption	NR	NR	NR	NR	NR	Fraction of the growing area directly over primary contamination.

[a] For truncated lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution, parameter 3 = lower quantile, and parameter 4 = upper quantile; for lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution; for triangular distribution, parameter 1 = minimum, parameter 2 = mode or most likely, and parameter 3 = maximum; for truncated normal distribution, parameter 1 = mean, parameter 2 = standard deviation, parameter 3 = lower quantile, and parameter 4 = upper quantile; for bounded lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution, parameter 3 = minimum value, and parameter 4 = maximum value; for uniform distribution, , parameter 1 = minimum, and parameter 2 = maximum; for continuous linear distribution, number of points, value of points, and CDF of points; for continuous logarithmic distribution, number of points, value of points, and CDF of points.
[b] P = physical, B = behavioral, and M = metabolic parameter.
[c] NA = not applicable.
[d] NR = not required.

Table B-42 Base Values and Statistical Distributions of Input Parameters Used in the RESRAD-OFFSITE Code for the Offsite Resident via Water Transport Scenario (cont.)

Input screen title/parameter	Units	Type[b]	Base value for deterministic calculation	Source	Probabilistic analysis[a]					Description
					Distribution	Parameter 1	Parameter 2	Parameter 3	Parameter 4	
Agricultural Areas (cont.)										
Fruit, grain, non-leafy										For description of parameters see description in contaminated zone and cover parameters.
Area of fruit, grain, and non-leafy vegetable plot	m^2	P	1000 (calculated from parameters in Site Layout Form)	Assumption	NR	NR	NR	NR	NR	Area for growing fruit, grain, and non-leafy vegetables.
Fraction of area of fruit, grain, and non-leafy vegetable plot directly over primary contamination	—	P	0	Assumption	NR	NR	NR	NR	NR	Fraction of the growing area directly over primary contamination.
Irrigation applied per year on fruit, grain, and non-leafy vegetable plot	m/yr	B	0.2	For deterministic run, base value selected is the code default. For probabilistic run, the minimum being 1/2 of the base value, and the maximum being two times the base value.	Uniform	0.1	0.4			See primary contamination irrigation rate.

[a] For truncated lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution, parameter 3 = lower quantile, and parameter 4 = upper quantile; for lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution; for triangular distribution, parameter 1 = minimum, parameter 2 = mode or most likely, and parameter 3 = maximum; for truncated normal distribution, parameter 1 = mean, parameter 2 = standard deviation, parameter 3 = lower quantile, and parameter 4 = upper quantile; for bounded lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution, parameter 3 = minimum value, and parameter 4 = maximum value; for uniform distribution, , parameter 1 = minimum, and parameter 2 = maximum; for continuous linear distribution, number of points, value of points, and CDF of points; for continuous logarithmic distribution, number of points, value of points, and CDF of points.

[b] P = physical, B = behavioral, and M = metabolic parameter.

[c] NA = not applicable.

[d] NR = not required.

Table B-42 Base Values and Statistical Distributions of Input Parameters Used in the RESRAD-OFFSITE Code for the Offsite Resident via Water Transport Scenario (cont.)

Input screen title/parameter	Units	Type[b]	Base value for deterministic calculation	Source	Probabilistic analysis[a]					Description
					Distribution	Parameter 1	Parameter 2	Parameter 3	Parameter 4	
Agricultural Areas (cont.)										
Evapotranspiration coefficient of fruit, grain, and non-leafy vegetable plot	—	P	0.5	For deterministic run, base value selected is the code default. For probabilistic run, the minimum value is 50 percent lower than the base value, and the maximum value is 50 percent higher than the base value.	Uniform,	0.25	0.75			See primary contamination evapotranspiration coefficient
Runoff coefficient of fruit, grain, and non-leafy vegetable plot	—	P	0.2	For deterministic run, base value selected is the code default. For probabilistic run, distribution from Yu et al. 2007 is used.	Uniform	0.1	0.8			See primary contamination runoff coefficient.

[a] For truncated lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution, parameter 3 = lower quantile, and parameter 4 = upper quantile; for lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution; for triangular distribution, parameter 1 = minimum, parameter 2 = mode or most likely, and parameter 3 = maximum; for truncated normal distribution, parameter 1 = mean, parameter 2 = standard deviation, parameter 3 = lower quantile, and parameter 4 = upper quantile; for bounded lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution, parameter 3 = minimum value, and parameter 4 = maximum value; for uniform distribution, , parameter 1 = minimum, and parameter 2 = maximum; for continuous linear distribution, number of points, value of points, and CDF of points; for continuous logarithmic distribution, number of points, value of points, and CDF of points.

[b] P = physical, B = behavioral, and M = metabolic parameter.

[c] NA = not applicable.

[d] NR = not required.

Table B-42 Base Values and Statistical Distributions of Input Parameters Used in the RESRAD-OFFSITE Code for the Offsite Resident via Water Transport Scenario (cont.)

Input screen title/parameter	Units	Type[b]	Base value for deterministic calculation	Source	Probabilistic analysis[a]					Description
					Distribution	Parameter 1	Parameter 2	Parameter 3	Parameter 4	
Agricultural Areas (cont.)										
Depth of soil mixing layer of fruit, grain, and non-leafy vegetable plot	m	P	0.15	For deterministic run, base value selected is the code default. For probabilistic run, distribution from Yu et al. 2007 is used.	Triangular	0	0.15	0.6		See primary contamination depth of soil mixing layer.
Volumetric water content of fruit, grain, and non-leafy vegetable plot	—	P	0.3	For deterministic run, base value selected is the code default. For probabilistic run, distribution from Yu et al. 2007 is used.	Continuous linear					See volumetric water content of clean cover.
Erosion rate of fruit, grain, and non-leafy vegetable plot	m/yr	NA	1.132E-5 (calculated)							Calculated from many uncertain parameters including soil erodibility factor
Dry bulk density of soil of fruit, grain, and non-leafy vegetable plot	g/cm^3	P	1.52	For deterministic run, base value selected is the code default. For probabilistic run, distribution from Yu et al. 2007 is used.	Truncated normal	1.52	0.23	0.001	0.999	See dry bulk density of clean cover

[a] For truncated lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution, parameter 3 = lower quantile, and parameter 4 = upper quantile; for lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution; for triangular distribution, parameter 1 = minimum, parameter 2 = mode or most likely, and parameter 3 = maximum; for truncated normal distribution, parameter 1 = mean, parameter 2 = standard deviation, parameter 3 = lower quantile, and parameter 4 = upper quantile; for bounded lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution, parameter 3 = minimum value, and parameter 4 = maximum value; for uniform distribution, , parameter 1 = minimum, and parameter 2 = maximum; for continuous linear distribution, number of points, value of points, and CDF of points; for continuous logarithmic distribution, number of points, value of points, and CDF of points.

[b] P = physical, B = behavioral, and M = metabolic parameter.

[c] NA = not applicable.

[d] NR = not required.

Table B-42 Base Values and Statistical Distributions of Input Parameters Used in the RESRAD-OFFSITE Code for the Offsite Resident via Water Transport Scenario (cont.)

Input screen title/parameter	Units	Type[b]	Base value for deterministic calculation	Source	Probabilistic analysis[a] Distribution	Parameter 1	Parameter 2	Parameter 3	Parameter 4	Description
Agricultural Areas (cont.)										
Soil erodibility factor of fruit, grain, and non-leafy vegetable plot	tons/acre	P	0.4	For deterministic run, base value selected is the code default. For probabilistic run, distribution from Yu et al. 2007 is used.	Continuous linear					See soil erodibility factor of clean cover
Slope-length-steepness factor of fruit, grain, and non-leafy vegetable plot	—	P	0.4	For deterministic run, base value selected is the code default. For probabilistic run, distribution from Yu et al. 2007 is used.	Continuous linear					See primary contamination slope-length-steepness factor
Cover and management factor of fruit, grain, and non-leafy vegetable plot	—	B, P	0.003	For deterministic run, base value selected is the code default. For probabilistic run, distribution from Yu et al. 2007 is used.	Continuous linear					See primary contamination cover and management factor

[a] For truncated lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution, parameter 3 = lower quantile, and parameter 4 = upper quantile; for lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution; for triangular distribution, parameter 1 = minimum, parameter 2 = mode or most likely, and parameter 3 = maximum; for truncated normal distribution, parameter 1 = mean, parameter 2 = standard deviation, parameter 3 = lower quantile, and parameter 4 = upper quantile; for bounded lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution, parameter 3 = minimum value, and parameter 4 = maximum value; for uniform distribution, , parameter 1 = minimum, and parameter 2 = maximum; for continuous linear distribution, number of points, value of points, and CDF of points; for continuous logarithmic distribution, number of points, value of points, and CDF of points.

[b] P = physical, B = behavioral, and M = metabolic parameter.

[c] NA = not applicable.

[d] NR = not required.

Table B-42 Base Values and Statistical Distributions of Input Parameters Used in the RESRAD-OFFSITE Code for the Offsite Resident via Water Transport Scenario (cont.)

Input screen title/parameter	Units	Type[b]	Base value for deterministic calculation	Source	Probabilistic analysis[a] Distribution	Parameter 1	Parameter 2	Parameter 3	Parameter 4	Description
Agricultural Areas (cont.)										
Support practice factor of fruit, grain, and non-leafy vegetable plot	—	B, P	1	For deterministic run, base value selected is the code default. For probabilistic run, distribution from Yu et al. 2007 is used.	Continuous linear					See primary contamination support practice factor
Total porosity of fruit, grain, and non-leafy vegetable plot	—	P	NR	NR	NR	NR	NR	NR	NR	See contaminated zone total porosity
Sediment from primary contamination delivery ratio	—	P	0							Value carried from Fate of Material Eroded from the Primary Contamination by Runoff Form
Leafy vegetables field For description see description in contaminated zone and cover parameters										
Area of leafy vegetable plot	m^2	P	Calculated1000 (calculated from parameters in Site Layout Form)							Area for growing leafy vegetables.
Fraction of area of leafy vegetable plot directly over primary contamination	—	P	0							Fraction of the growing area directly over primary contamination.
Irrigation applied per year on leafy vegetable plot	m/yr	B	0.2	For deterministic run, base value selected is the code default. For probabilistic run, the minimum being 1/2 of the base value, and the maximum being two times the base value.	Uniform	0.1	0.4			See primary contamination irrigation rate

[a] For truncated lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution, parameter 3 = lower quantile, and parameter 4 = upper quantile; for lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution; for triangular distribution, parameter 1 = minimum, parameter 2 = mode or most likely, and parameter 3 = maximum; for truncated normal distribution, parameter 1 = mean, parameter 2 = standard deviation, parameter 3 = lower quantile, and parameter 4 = upper quantile; for bounded lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution, parameter 3 = minimum value, and parameter 4 = maximum value; for uniform distribution, , parameter 1 = minimum, and parameter 2 = maximum; for continuous linear distribution, number of points, value of points, and CDF of points; for continuous logarithmic distribution, number of points, value of points, and CDF of points.

[b] P = physical, B = behavioral, and M = metabolic parameter.

[c] NA = not applicable.

[d] NR = not required.

Table B-42 Base Values and Statistical Distributions of Input Parameters Used in the RESRAD-OFFSITE Code for the Offsite Resident via Water Transport Scenario (cont.)

Input screen title/parameter	Units	Type[b]	Base value for deterministic calculation	Source	Probabilistic analysis[a] Distribution	Parameter 1	Parameter 2	Parameter 3	Parameter 4	Description
Leafy vegetables field (cont.) For description see description in contaminated zone and cover parameters										
Evapotranspiration coefficient of leafy vegetable plot	—	P	0.5	For deterministic run, base value selected is the code default. For probabilistic run, minimum 50 percent lower than the base value, and maximum 50 percent higher than the base value is used.	Uniform	0.25	0.75			See primary contamination evapotranspiration coefficient
Runoff coefficient of leafy vegetable plot	—	P	0.2	For deterministic run, base value selected is the code default. For probabilistic run, distribution from NUREG/CR-6697 is used.	Uniform	0.1	0.8			See primary contamination runoff coefficient
Depth of soil mixing layer of leafy vegetable plot	m	P	0.15	For deterministic run, base value selected is the median from the distribution. For probabilistic run, distribution from NUREG/CR-6697 is used.	Triangular	0	0.15	0.6		See primary contamination depth of soil mixing layer

[a] For truncated lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution, parameter 3 = lower quantile, and parameter 4 = upper quantile; for lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution; for triangular distribution, parameter 1 = minimum, parameter 2 = mode or most likely, and parameter 3 = maximum; for truncated normal distribution, parameter 1 = mean, parameter 2 = standard deviation, parameter 3 = lower quantile, and parameter 4 = upper quantile; for bounded lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution, parameter 3 = minimum value, and parameter 4 = maximum value; for uniform distribution, , parameter 1 = minimum, and parameter 2 = maximum; for continuous linear distribution, number of points, value of points, and CDF of points; for continuous logarithmic distribution, number of points, value of points, and CDF of points.

[b] P = physical, B = behavioral, and M = metabolic parameter.

[c] NA = not applicable.

[d] NR = not required.

Table B-42 Base Values and Statistical Distributions of Input Parameters Used in the RESRAD-OFFSITE Code for the Offsite Resident via Water Transport Scenario (cont.)

Input screen title/parameter	Units	Type[b]	Base value for deterministic calculation	Source	Probabilistic analysis[a]					Description
					Distribution	Parameter 1	Parameter 2	Parameter 3	Parameter 4	
Leafy vegetables field (cont.) For description see description in contaminated zone and cover parameters										
Volumetric water content of leafy vegetable plot	—	P	0.3	For deterministic run, base value selected is the code default. For probabilistic run, distribution from Yu et al. 2007 is used.	Continuous linear					See volumetric water content of clean cover
Erosion rate of leafy vegetable plot	m/yr	NA	1.132E-5 (calculated)							Calculated from many uncertain parameters including soil erodibility factor
Dry bulk density of soil of leafy vegetable plot	g/cm^3	P	1.52	For deterministic run, base value selected is the mean from the distribution. For probabilistic run, distribution from NUREG/CR-6697 is used.	Truncated normal	1.52	0.23	0.001	0.999	See dry bulk density of clean cover
Soil erodibility factor of leafy vegetable plot	tons/acre	P	0.4	For deterministic run, base value selected is the code default. For probabilistic run, distribution from Yu et al. 2007 is used.	Continuous linear					See soil erodibility factor of clean cover

[a] For truncated lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution, parameter 3 = lower quantile, and parameter 4 = upper quantile; for lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution; for triangular distribution, parameter 1 = minimum, parameter 2 = mode or most likely, and parameter 3 = maximum; for truncated normal distribution, parameter 1 = mean, parameter 2 = standard deviation, parameter 3 = lower quantile, and parameter 4 = upper quantile; for bounded lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution, parameter 3 = minimum value, and parameter 4 = maximum value; for uniform distribution, , parameter 1 = minimum, and parameter 2 = maximum; for continuous linear distribution, number of points, value of points, and CDF of points; for continuous logarithmic distribution, number of points, value of points, and CDF of points.

[b] P = physical, B = behavioral, and M = metabolic parameter.

[c] NA = not applicable.

[d] NR = not required.

Table B-42 Base Values and Statistical Distributions of Input Parameters Used in the RESRAD-OFFSITE Code for the Offsite Resident via Water Transport Scenario (cont.)

Input screen title/parameter	Units	Type[b]	Base value for deterministic calculation	Source	Probabilistic analysis[a] Distribution	Parameter 1	Parameter 2	Parameter 3	Parameter 4	Description
Leafy vegetables field (cont.) For description see description in contaminated zone and cover parameters										
Slope-length-steepness factor of leafy vegetable plot	—	P	0.4	For deterministic run, base value selected is the code default. For probabilistic run, distribution from Yu et al. 2007 is used.	Continuous linear					See primary contamination slope-length-steepness factor
Cover and management factor of leafy vegetable plot	—	B, P	0.003	For deterministic run, base value selected is the code default. For probabilistic run, distribution from Yu et al. 2007 is used.	Continuous linear					See primary contamination cover and management factor
Support practice factor of leafy vegetable plot	—	B, P	1	For deterministic run, base value selected is the code default. For probabilistic run, distribution from Yu et al. 2007 is used.	Continuous linear					See primary contamination support practice factor
Total porosity of leafy vegetable plot	—	P	NR	NR	NR	NR	NR	NR	NR	See contaminated zone total porosity
Sediment from primary contamination delivery ratio	—	P	0							Value carried from Fate of Material Eroded from the Primary Contamination by Runoff Form

[a] For truncated lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution, parameter 3 = lower quantile, and parameter 4 = upper quantile; for lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution; for triangular distribution, parameter 1 = minimum, parameter 2 = mode or most likely, and parameter 3 = maximum; for truncated normal distribution, parameter 1 = mean, parameter 2 = standard deviation, parameter 3 = lower quantile, and parameter 4 = upper quantile; for bounded lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution, parameter 3 = minimum value, and parameter 4 = maximum value; for uniform distribution, , parameter 1 = minimum, and parameter 2 = maximum; for continuous linear distribution, number of points, value of points, and CDF of points; for continuous logarithmic distribution, number of points, value of points, and CDF of points.

[b] P = physical, B = behavioral, and M = metabolic parameter.

[c] NA = not applicable.

[d] NR = not required.

Table B-42 Base Values and Statistical Distributions of Input Parameters Used in the RESRAD-OFFSITE Code for the Offsite Resident via Water Transport Scenario (cont.)

Input screen title/parameter	Units	Type[b]	Base value for deterministic calculation	Source	Probabilistic analysis[a] Distribution	Parameter 1	Parameter 2	Parameter 3	Parameter 4	Description
Livestock feed growing areas										
Pasture and silage growing area For description see description in contaminated zone and cover parameters										
Area of pasture and silage feed	m^2	P	10,000 (calculated from parameters in Site Layout Form)							Area for growing pasture and silage.
Fraction of area of pasture and silage feed plot directly over primary contamination	—	P	0							Fraction of the growing area directly over primary contamination.
Irrigation applied per year on pasture and silage feed plot	m/yr	B	0.2	For deterministic run, base value selected is the code default. For probabilistic run, the minimum being 1/2 of the base value, and the maximum being two times the base value.	Uniform	0.1	0.4			See primary contamination irrigation rate
Evapotranspiration coefficient of pasture and silage feed plot	—	P	0.5	For deterministic run, base value selected is the code default. For probabilistic run, minimum value is 50 percent lower than the base value and maximum value is 50 percent higher than the base value.	Uniform	0.25	0.75			See primary contamination evapotranspiration coefficient

[a] For truncated lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution, parameter 3 = lower quantile, and parameter 4 = upper quantile; for lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution; for triangular distribution, parameter 1 = minimum, parameter 2 = mode or most likely, and parameter 3 = maximum; for truncated normal distribution, parameter 1 = mean, parameter 2 = standard deviation, parameter 3 = lower quantile, and parameter 4 = upper quantile; for bounded lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution, parameter 3 = minimum value, and parameter 4 = maximum value; for uniform distribution, , parameter 1 = minimum, and parameter 2 = maximum; for continuous linear distribution, number of points, value of points, and CDF of points; for continuous logarithmic distribution, number of points, value of points, and CDF of points.

[b] P = physical, B = behavioral, and M = metabolic parameter.

[c] NA = not applicable.

[d] NR = not required.

Table B-42 Base Values and Statistical Distributions of Input Parameters Used in the RESRAD-OFFSITE Code for the Offsite Resident via Water Transport Scenario (cont.)

Input screen title/parameter	Units	Type[b]	Base value for deterministic calculation	Source	Probabilistic analysis[a] Distribution	Parameter 1	Parameter 2	Parameter 3	Parameter 4	Description
Livestock feed growing areas (cont.)										
Pasture and silage growing area (cont.) For description see description in contaminated zone and cover parameters										
Runoff coefficient of pasture and silage feed plot	—	P	0.2	For deterministic run, base value selected is the code default. For probabilistic run, distribution from NUREG/CR-6697 is used.	Uniform	0.1	0.8			See primary contamination runoff coefficient
Depth of soil mixing layer of pasture and silage feed plot	m	P	0.15	For deterministic run, base value selected is the median from the distribution. For probabilistic run, distribution from NUREG/CR-6697 is used.	Triangular	0	0.15	0.6		See primary contamination depth of soil mixing layer
Volumetric water content of pasture and silage feed plot	—	P	0.3	For deterministic run, base value selected is the code default. For probabilistic run, distribution from Yu et al. 2007 is used.	Continuous linear					See volumetric water content of clean cover
Erosion rate of pasture and silage feed plot	m/yr	NA	1.132E-5 (calculated)	Calculated						Calculated from many uncertain parameters including soil erodibility factor

[a] For truncated lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution, parameter 3 = lower quantile, and parameter 4 = upper quantile; for lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution; for triangular distribution, parameter 1 = minimum, parameter 2 = mode or most likely, and parameter 3 = maximum; for truncated normal distribution, parameter 1 = mean, parameter 2 = standard deviation, parameter 3 = lower quantile, and parameter 4 = upper quantile; for bounded lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution, parameter 3 = minimum value, and parameter 4 = maximum value; for uniform distribution, , parameter 1 = minimum, and parameter 2 = maximum; for continuous linear distribution, number of points, value of points, and CDF of points; for continuous logarithmic distribution, number of points, value of points, and CDF of points.
[b] P = physical, B = behavioral, and M = metabolic parameter.
[c] NA = not applicable.
[d] NR = not required.

Table B-42 Base Values and Statistical Distributions of Input Parameters Used in the RESRAD-OFFSITE Code for the Offsite Resident via Water Transport Scenario (cont.)

Input screen title/parameter	Units	Type[b]	Base value for deterministic calculation	Source	Probabilistic analysis[a]					Description
					Distribution	Parameter 1	Parameter 2	Parameter 3	Parameter 4	
Livestock feed growing areas (cont.)										
Pasture and silage growing area (cont.) For description see description in contaminated zone and cover parameters										
Dry bulk density of soil of pasture and silage feed plot	g/cm^3	P	1.52	For deterministic run, base value selected is the mean from the distribution. For probabilistic run, distribution from NUREG/CR-6697 is used.	Truncated normal	1.52	0.23	0.001	0.999	See dry bulk density of clean cover
Soil erodibility factor of pasture and silage feed plot	tons/acre	P	0.4	For deterministic run, base value selected is the code default. For probabilistic run, distribution from Yu et al. 2007 is used.	Continuous linear					See soil erodibility factor of clean cover
Slope-length-steepness factor of pasture and silage feed plot	—	P	0.4	For deterministic run, base value selected is the code default. For probabilistic run, distribution from Yu et al. 2007 is used.	Continuous linear					See primary contamination slope-length-steepness factor

[a] For truncated lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution, parameter 3 = lower quantile, and parameter 4 = upper quantile; for lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution; for triangular distribution, parameter 1 = minimum, parameter 2 = mode or most likely, and parameter 3 = maximum; for truncated normal distribution, parameter 1 = mean, parameter 2 = standard deviation, parameter 3 = lower quantile, and parameter 4 = upper quantile; for bounded lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution, parameter 3 = minimum value, and parameter 4 = maximum value; for uniform distribution, , parameter 1 = minimum, and parameter 2 = maximum; for continuous linear distribution, number of points, value of points, and CDF of points; for continuous logarithmic distribution, number of points, value of points, and CDF of points.

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[c] NA = not applicable.

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Table B-42 Base Values and Statistical Distributions of Input Parameters Used in the RESRAD-OFFSITE Code for the Offsite Resident via Water Transport Scenario (cont.)

Input screen title/parameter	Units	Type[b]	Base value for deterministic calculation	Source	Probabilistic analysis[a]					Description
					Distribution	Parameter 1	Parameter 2	Parameter 3	Parameter 4	
Livestock feed growing areas (cont.)										
Pasture and silage growing area (cont.) For description see description in contaminated zone and cover parameters										
Cover and management factor of pasture and silage feed plot	—	B, P	0.003	For deterministic run, base value selected is the code default. For probabilistic run, distribution from Yu et al. 2007 is used.	Continuous linear					See primary contamination cover and management factor
Support practice factor of pasture and silage feed plot	—	, P	1	For deterministic run, base value selected is the code default. For probabilistic run, distribution from Yu et al. 2007 is used.	Continuous linear					See primary contamination support practice factor
Total porosity of pasture and silage feed plot	—	P	NR	NR	NR	NR	NR	NR	NR	See contaminated zone total porosity
Sediment from primary contamination delivery ratio	—	P	0							Value carried from Fate of Material Eroded from the Primary Contamination by Runoff Form
Grain growing area For description see description in contaminated zone and cover parameters										
Area of grain feed	m^2	P	10,000 (calculated from parameters in Site Layout Form)							Area for growing grain.
Fraction of area of grain feed plot directly over primary contamination	—	P	0							Fraction of the growing area directly over primary contamination.

[a] For truncated lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution, parameter 3 = lower quantile, and parameter 4 = upper quantile; for lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution; for triangular distribution, parameter 1 = minimum, parameter 2 = mode or most likely, and parameter 3 = maximum; for truncated normal distribution, parameter 1 = mean, parameter 2 = standard deviation, parameter 3 = lower quantile, and parameter 4 = upper quantile; for bounded lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution, parameter 3 = minimum value, and parameter 4 = maximum value; for uniform distribution, , parameter 1 = minimum, and parameter 2 = maximum; for continuous linear distribution, number of points, value of points, and CDF of points; for continuous logarithmic distribution, number of points, value of points, and CDF of points.

[b] P = physical, B = behavioral, and M = metabolic parameter.

[c] NA = not applicable.

[d] NR = not required.

Table B-42 Base Values and Statistical Distributions of Input Parameters Used in the RESRAD-OFFSITE Code for the Offsite Resident via Water Transport Scenario (cont.)

Input screen title/parameter	Units	Type[b]	Base value for deterministic calculation	Source	Probabilistic analysis[a]					Description
					Distribution	Parameter 1	Parameter 2	Parameter 3	Parameter 4	
Livestock feed growing areas (cont.)										
Grain growing area (cont.) For description see description in contaminated zone and cover parameters										
Irrigation applied per year on grain feed plot	m/yr	B	0.2	For deterministic run, base value selected is the code default. For probabilistic run, the minimum being 1/2 of the base value, and the maximum being two times the base value.	Uniform	0.1	0.3			See primary contamination irrigation rate
Evapotranspiration coefficient of grain feed plot	—	P	0.5	For deterministic run, base value selected is the code default. For probabilistic run, the minimum value is 50 percent lower than the base value and the maximum value is 50 percent higher than the base value.	Uniform	0.25	0.75			See primary contamination evapotranspiration coefficient

[a] For truncated lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution, parameter 3 = lower quantile, and parameter 4 = upper quantile; for lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution; for triangular distribution, parameter 1 = minimum, parameter 2 = mode or most likely, and parameter 3 = maximum; for truncated normal distribution, parameter 1 = mean, parameter 2 = standard deviation, parameter 3 = lower quantile, and parameter 4 = upper quantile; for bounded lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution, parameter 3 = minimum value, and parameter 4 = maximum value; for uniform distribution, , parameter 1 = minimum, and parameter 2 = maximum; for continuous linear distribution, number of points, value of points, and CDF of points; for continuous logarithmic distribution, number of points, value of points, and CDF of points.

[b] P = physical, B = behavioral, and M = metabolic parameter.

[c] NA = not applicable.

[d] NR = not required.

Table B-42 Base Values and Statistical Distributions of Input Parameters Used in the RESRAD-OFFSITE Code for the Offsite Resident via Water Transport Scenario (cont.)

Input screen title/parameter	Units	Type[b]	Base value for deterministic calculation	Source	Probabilistic analysis[a]					Description
					Distribution	Parameter 1	Parameter 2	Parameter 3	Parameter 4	
Livestock feed growing areas (cont.)										
Grain growing area (cont.) For description see description in contaminated zone and cover parameters										
Runoff coefficient of grain feed plot	—	P	0.2	For deterministic run, base value selected is the code default. For probabilistic run, distribution from NUREG/CR-6697 is used.	Uniform	0.1	0.8			See primary contamination runoff coefficient
Depth of soil mixing layer of grain feed plot	m	P	0.15	For deterministic run, base value selected is the median from the distribution. For probabilistic run, distribution from NUREG/CR-6697 is used.	Triangular	0	0.15	0.6		See primary contamination depth of soil mixing layer
Volumetric water content of grain feed plot	—	P	0.3	For deterministic run, base value selected is the code default. For probabilistic run, distribution from Yu et al. 2007 is used.	Continuous linear					See volumetric water content of clean cover
Erosion rate of grain feed plot	m/yr	NA	1.132E-5 (calculated)							Calculated from many uncertain parameters including soil erodibility factor

[a] For truncated lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution, parameter 3 = lower quantile, and parameter 4 = upper quantile; for lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution; for triangular distribution, parameter 1 = minimum, parameter 2 = mode or most likely, and parameter 3 = maximum; for truncated normal distribution, parameter 1 = mean, parameter 2 = standard deviation, parameter 3 = lower quantile, and parameter 4 = upper quantile; for bounded lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution, parameter 3 = minimum value, and parameter 4 = maximum value; for uniform distribution, , parameter 1 = minimum, and parameter 2 = maximum; for continuous linear distribution, number of points, value of points, and CDF of points; for continuous logarithmic distribution, number of points, value of points, and CDF of points.

[b] P = physical, B = behavioral, and M = metabolic parameter.

[c] NA = not applicable.

[d] NR = not required.

Table B-42 Base Values and Statistical Distributions of Input Parameters Used in the RESRAD-OFFSITE Code for the Offsite Resident via Water Transport Scenario (cont.)

Input screen title/parameter	Units	Type[b]	Base value for deterministic calculation	Source	Probabilistic analysis[a] Distribution	Parameter 1	Parameter 2	Parameter 3	Parameter 4	Description
Livestock feed growing areas (cont.)										
Grain growing area (cont.) For description see description in contaminated zone and cover parameters										
Dry bulk density of soil of grain feed plot	g/cm^3	P	1.52	For deterministic run, base value selected is the mean from the distribution. For probabilistic run, distribution from NUREG/CR-6697 is used.	Truncated normal	1.52	0.23	0.001	0.999	See dry bulk density of clean cover
Soil erodibility factor of grain feed plot	tons/acre	P	0.4	For deterministic run, the base selected is the code default. For probabilistic run, distribution from Yu et al. 2007 is used.	Continuous linear					See soil erodibility factor of clean cover
Slope-length-steepness factor of grain feed plot	—	P	0.4	For deterministic run, base value selected is the code default. For probabilistic run, distribution from Yu et al. 2007 is used.	Continuous linear					See primary contamination slope-length-steepness factor

[a] For truncated lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution, parameter 3 = lower quantile, and parameter 4 = upper quantile; for lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution; for triangular distribution, parameter 1 = minimum, parameter 2 = mode or most likely, and parameter 3 = maximum; for truncated normal distribution, parameter 1 = mean, parameter 2 = standard deviation, parameter 3 = lower quantile, and parameter 4 = upper quantile; for bounded lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution, parameter 3 = minimum value, and parameter 4 = maximum value; for uniform distribution, , parameter 1 = minimum, and parameter 2 = maximum; for continuous linear distribution, number of points, value of points, and CDF of points; for continuous logarithmic distribution, number of points, value of points, and CDF of points.

[b] P = physical, B = behavioral, and M = metabolic parameter.

[c] NA = not applicable.

[d] NR = not required.

Table B-42 Base Values and Statistical Distributions of Input Parameters Used in the RESRAD-OFFSITE Code for the Offsite Resident via Water Transport Scenario (cont.)

Input screen title/parameter	Units	Type[b]	Base value for deterministic calculation	Source	Probabilistic analysis[a] Distribution	Parameter 1	Parameter 2	Parameter 3	Parameter 4	Description
Livestock feed growing areas (cont.)										
Grain growing area (cont.) For description see description in contaminated zone and cover parameters										
Cover and management factor of grain feed plot	—	B, P	0.003	For deterministic run, base value selected is the code default. For probabilistic run, distribution from Yu et al. 2007 is used.	Continuous linear					See primary contamination cover and management factor
Support practice factor of grain feed plot	—	B, P	1	For deterministic run, base value selected is the code default. For probabilistic run, distribution from Yu et al. 2007 is used.	Continuous linear					See primary contamination support practice factor
Total porosity of grain feed plot	—	P	NR	NR	NR	NR	NR	NR	NR	See contaminated zone total porosity
Sediment from primary contamination delivery ratio	—	P	0							Value carried from Fate of Material Eroded from the Primary Contamination by Runoff Form
Offsite dwelling area										
Area of offsite dwelling	m^2	P	1,000 (calculated from parameters in Site Layout Form)							

[a] For truncated lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution, parameter 3 = lower quantile, and parameter 4 = upper quantile; for lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution; for triangular distribution, parameter 1 = minimum, parameter 2 = mode or most likely, and parameter 3 = maximum; for truncated normal distribution, parameter 1 = mean, parameter 2 = standard deviation, parameter 3 = lower quantile, and parameter 4 = upper quantile; for bounded lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution, parameter 3 = minimum value, and parameter 4 = maximum value; for uniform distribution, , parameter 1 = minimum, and parameter 2 = maximum; for continuous linear distribution, number of points, value of points, and CDF of points; for continuous logarithmic distribution, number of points, value of points, and CDF of points.

[b] P = physical, B = behavioral, and M = metabolic parameter.

[c] NA = not applicable.

[d] NR = not required.

Table B-42 Base Values and Statistical Distributions of Input Parameters Used in the RESRAD-OFFSITE Code for the Offsite Resident via Water Transport Scenario (cont.)

Input screen title/parameter	Units	Type[b]	Base value for deterministic calculation	Source	Probabilistic analysis[a]					Description
					Distribution	Parameter 1	Parameter 2	Parameter 3	Parameter 4	
Offsite dwelling area (cont.)										
Area of offsite dwelling	m^2	P	1,000 (calculated from parameters in Site Layout Form)							
Irrigation applied per year on offsite dwelling area	m/yr	B	0.2	For deterministic run, base value selected is the code default. For probabilistic run, the minimum being 1/2 of the base value, and the maximum being two times the base value.	Uniform	0.1	0.4			See primary contamination irrigation rate
Evapotranspiration coefficient of offsite dwelling area	—	P	0.5	For deterministic run, base value selected is the code default.	None	NR	NR	NR	NR	See primary contamination evapotranspiration coefficient
Runoff coefficient of offsite dwelling area	—	P	0.2	For deterministic run, base value selected is the code default. For probabilistic run, distribution from NUREG/CR-6697 is used.	Uniform	0.1	0.8			See primary contamination runoff coefficient

[a] For truncated lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution, parameter 3 = lower quantile, and parameter 4 = upper quantile; for lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution; for triangular distribution, parameter 1 = minimum, parameter 2 = mode or most likely, and parameter 3 = maximum; for truncated normal distribution, parameter 1 = mean, parameter 2 = standard deviation, parameter 3 = lower quantile, and parameter 4 = upper quantile; for bounded lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution, parameter 3 = minimum value, and parameter 4 = maximum value; for uniform distribution, , parameter 1 = minimum, and parameter 2 = maximum; for continuous linear distribution, number of points, value of points, and CDF of points; for continuous logarithmic distribution, number of points, value of points, and CDF of points.

[b] P = physical, B = behavioral, and M = metabolic parameter.

[c] NA = not applicable.

[d] NR = not required.

Table B-42 Base Values and Statistical Distributions of Input Parameters Used in the RESRAD-OFFSITE Code for the Offsite Resident via Water Transport Scenario (cont.)

Input screen title/parameter	Units	Type[b]	Base value for deterministic calculation	Source	Probabilistic analysis[a]					Description
					Distribution	Parameter 1	Parameter 2	Parameter 3	Parameter 4	
Offsite dwelling area (cont.)										
Depth of soil mixing layer of offsite dwelling area	m	P	0.15	For deterministic run, base value selected is the median from the distribution. For probabilistic run, distribution from NUREG/CR-6697 is used.	Triangular	0	0.15	0.6		See primary contamination depth of soil mixing layer
Volumetric water content of offsite dwelling area	—	P	0.3	For deterministic run, base value selected is the code default. For probabilistic run, distribution from Yu et al. 2007 is used.	Continuous linear					See volumetric water content of clean cover
Erosion rate of offsite dwelling area	m/yr	NA	Calculated		NR	NR	NR	NR	NR	Calculated from many uncertain parameters including soil erodibility factor
Dry bulk density of soil of offsite dwelling area	g/cm^3	P	1.52	For deterministic run, base value selected is the mean from the distribution. For probabilistic run, distribution from NUREG/CR-6697 is used.	Truncated normal	1.52	0.23	0.001	0.999	See dry bulk density of clean cover

[a] For truncated lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution, parameter 3 = lower quantile, and parameter 4 = upper quantile; for lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution; for triangular distribution, parameter 1 = minimum, parameter 2 = mode or most likely, and parameter 3 = maximum; for truncated normal distribution, parameter 1 = mean, parameter 2 = standard deviation, parameter 3 = lower quantile, and parameter 4 = upper quantile; for bounded lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution, parameter 3 = minimum value, and parameter 4 = maximum value; for uniform distribution, , parameter 1 = minimum, and parameter 2 = maximum; for continuous linear distribution, number of points, value of points, and CDF of points; for continuous logarithmic distribution, number of points, value of points, and CDF of points.

[b] P = physical, B = behavioral, and M = metabolic parameter.

[c] NA = not applicable.

[d] NR = not required.

Table B-42 Base Values and Statistical Distributions of Input Parameters Used in the RESRAD-OFFSITE Code for the Offsite Resident via Water Transport Scenario (cont.)

Input screen title/parameter	Units	Type[b]	Base value for deterministic calculation	Source	Probabilistic analysis[a]					Description
					Distribution	Parameter 1	Parameter 2	Parameter 3	Parameter 4	
Offsite dwelling area (cont.)										
Soil erodibility factor of offsite dwelling area	tons/acre	P	0	For deterministic run, base value selected is the code default.	None	NR	NR	NR	NR	See soil erodibility factor of clean cover
Slope-length-steepness factor of offsite dwelling area	—	P	0.4	For deterministic run, base value selected is the code default.	None	NR	NR	NR	NR	See primary contamination slope-length-steepness factor
Cover and management factor of offsite dwelling area	—	B, P	0.003	For deterministic run, base value selected is the code default. For probabilistic run, distribution from Yu et al. 2007 is used.	Continuous linear					See primary contamination cover and management factor.
Support practice factor of offsite dwelling area	—	B, P	1	For deterministic run, base value selected is the code default. For probabilistic run, distribution from Yu et al. 2007 is used.	Continuous linear					See primary contamination support practice factor.
Total porosity of offsite dwelling area	—	P	NR	Not required	NR	NR	NR	NR	NR	See contaminated zone total porosity.
Sediment from primary contamination delivery ratio	—	P	0							Value carried from Fate of Material Eroded from the Primary Contamination by Runoff Form.

[a] For truncated lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution, parameter 3 = lower quantile, and parameter 4 = upper quantile; for lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution; for triangular distribution, parameter 1 = minimum, parameter 2 = mode or most likely, and parameter 3 = maximum; for truncated normal distribution, parameter 1 = mean, parameter 2 = standard deviation, parameter 3 = lower quantile, and parameter 4 = upper quantile; for bounded lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution, parameter 3 = minimum value, and parameter 4 = maximum value; for uniform distribution, , parameter 1 = minimum, and parameter 2 = maximum; for continuous linear distribution, number of points, value of points, and CDF of points; for continuous logarithmic distribution, number of points, value of points, and CDF of points.

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[c] NA = not applicable.

[d] NR = not required.

Table B-42 Base Values and Statistical Distributions of Input Parameters Used in the RESRAD-OFFSITE Code for the Offsite Resident via Water Transport Scenario (cont.)

Input screen title/parameter	Units	Type[b]	Base value for deterministic calculation	Source	Probabilistic analysis[a] Distribution	Parameter 1	Parameter 2	Parameter 3	Parameter 4	Description
Atmospheric transport										
Release height	m	P	1	For deterministic run, base value selected is the code default.	None	NR	NR	NR	NR	Physical release height of escaped material.
Release heat flux	cal/s	P	0	For deterministic run, base value selected is the code default.	None	NR	NR	NR	NR	The heat energy associated with the contaminant release.
Anemometer height	m	P	10	For deterministic run, base value selected is the code default.	None	NR	NR	NR	NR	The height at which the value for wind speed is measured.
Ambient temperature	K	P	285	For deterministic run, base value selected is the code default.	None	NR	NR	NR	NR	Ambient temperature used in the calculation of plume rise of escaped material.
AM atmospheric mixing height	m	P	400	For deterministic run, base value selected is the code default.	None	NR	NR	NR	NR	The annual average morning mixing height. The annual average morning mixing height and the annual afternoon mixing height are used to determine the mixing height for different Pasquill stability classes.
PM atmospheric mixing height	m	P	1,600	For deterministic run, base value selected is the code default.	None	NR	NR	NR	NR	The annual afternoon mixing height.
Dispersion model coefficients	—	P	Pasquill-Gifford Coefficients	For deterministic run, base value selected is the code default.	None	NR	NR	NR	NR	Controls dispersion coefficients used for the plume dispersion calculations. Pasquill-Gifford coefficients used for releases at or near ground level.

[a] For truncated lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution, parameter 3 = lower quantile, and parameter 4 = upper quantile; for lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution; for triangular distribution, parameter 1 = minimum, parameter 2 = mode or most likely, and parameter 3 = maximum; for truncated normal distribution, parameter 1 = mean, parameter 2 = standard deviation, parameter 3 = lower quantile, and parameter 4 = upper quantile; for bounded lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution, parameter 3 = minimum value, and parameter 4 = maximum value; for uniform distribution, , parameter 1 = minimum, and parameter 2 = maximum; for continuous linear distribution, number of points, value of points, and CDF of points; for continuous logarithmic distribution, number of points, value of points, and CDF of points.

[b] P = physical, B = behavioral, and M = metabolic parameter.

[c] NA = not applicable.

[d] NR = not required.

Table B-42 Base Values and Statistical Distributions of Input Parameters Used in the RESRAD-OFFSITE Code for the Offsite Resident via Water Transport Scenario (cont.)

Input screen title/parameter	Units	Type[b]	Base value for deterministic calculation	Source	Probabilistic analysis[a]					Description
					Distribution	Parameter 1	Parameter 2	Parameter 3	Parameter 4	
Atmospheric transport (cont.)										
Windspeed Terrain	—	P	Rural	For deterministic run, base value selected is the code default.	None	NR	NR	NR	NR	Wind speed terrain selection affects air dispersion.
Elevation of fruit, grain, non-leafy vegetable plot relative to primary contamination (PC)	m	P	0	For deterministic run, base value selected is the code default.	None	NR	NR	NR	NR	When the ground level at the offsite location is above the ground level at the vicinity of the primary contamination, the code adjusts for the upward deflection of the wind. The difference in the height of the ground surface at the off-site location of contaminant accumulation and its height around the site of primary contamination.
Elevation of leafy vegetable plot relative to PC	m	P	0	For deterministic run, base value selected is the code default.	None	NR	NR	NR	NR	See above
Elevation of pasture silage growing area relative to PC	m	P	0	For deterministic run, base value selected is the code default.	None	NR	NR	NR	NR	See above
Elevation of grain fields relative to PC	m	P	0	For deterministic run, base value selected is the code default.	None	NR	NR	NR	NR	See above
Elevation of dwelling site relative to PC	m	P	0	For deterministic run, base value selected is the code default.	None	NR	NR	NR	NR	See above

[a] For truncated lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution, parameter 3 = lower quantile, and parameter 4 = upper quantile; for lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution; for triangular distribution, parameter 1 = minimum, parameter 2 = mode or most likely, and parameter 3 = maximum; for truncated normal distribution, parameter 1 = mean, parameter 2 = standard deviation, parameter 3 = lower quantile, and parameter 4 = upper quantile; for bounded lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution, parameter 3 = minimum value, and parameter 4 = maximum value; for uniform distribution, , parameter 1 = minimum, and parameter 2 = maximum; for continuous linear distribution, number of points, value of points, and CDF of points; for continuous logarithmic distribution, number of points, value of points, and CDF of points.
[b] P = physical, B = behavioral, and M = metabolic parameter.
[c] NA = not applicable.
[d] NR = not required.

Table B-42 Base Values and Statistical Distributions of Input Parameters Used in the RESRAD-OFFSITE Code for the Offsite Resident via Water Transport Scenario (cont.)

Input screen title/parameter	Units	Type[b]	Base value for deterministic calculation	Source	Probabilistic analysis[a]					Description
					Distribution	Parameter 1	Parameter 2	Parameter 3	Parameter 4	
Atmospheric transport (cont.)										
Elevation of dwelling site relative to PC	m	P	0	For deterministic run, base value selected is the code default.	None	NR	NR	NR	NR	See above
Elevation of surface water body relative to PC	m	P	0	For deterministic run, base value selected is the code default.	None	NR	NR	NR	NR	See above
Grid spacing for areal integration	m	NA	10	For deterministic run, base value selected is the code default.	None	NR	NR	NR	NR	See above
Joint frequency of wind speed and stability class for a 16-sector wind rose	—	P	Input value							Wind blowing with average speed of 0.89 m/s from S to N in stability classes D, E, and F in 0.1, 0.2, and 0.7 fractions, respectively. For the receptor and accumulation locations in this scenario, the wind blowing from S to N in stability classes D, E, and F will give a higher dose for a near ground level release as there is less dispersion in these cases.
Unsaturated Zone Hydrology										
Number of unsaturated zones	—	P	1	For deterministic run, base value selected is the code default.	None	NR	NR	NR	NR	

[a] For truncated lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution, parameter 3 = lower quantile, and parameter 4 = upper quantile; for lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution; for triangular distribution, parameter 1 = minimum, parameter 2 = mode or most likely, and parameter 3 = maximum; for truncated normal distribution, parameter 1 = mean, parameter 2 = standard deviation, parameter 3 = lower quantile, and parameter 4 = upper quantile; for bounded lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution, parameter 3 = minimum value, and parameter 4 = maximum value; for uniform distribution, , parameter 1 = minimum, and parameter 2 = maximum; for continuous linear distribution, number of points, value of points, and CDF of points; for continuous logarithmic distribution, number of points, value of points, and CDF of points.

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[c] NA = not applicable.

[d] NR = not required.

Table B-42 Base Values and Statistical Distributions of Input Parameters Used in the RESRAD-OFFSITE Code for the Offsite Resident via Water Transport Scenario (cont.)

Input screen title/parameter	Units	Type[b]	Base value for deterministic calculation	Source	Probabilistic analysis[a]					Description
					Distribution	Parameter 1	Parameter 2	Parameter 3	Parameter 4	
Unsaturated Zone Hydrology (cont.)										
Unsaturated zone thickness	m	P	4	For deterministic run, base value selected is the code default. For probabilistic run, distribution from NUREG/CR-6697 is used.	Bounded lognormal-N	2.296	1.276	0.18	320	The thickness of the specific unsaturated zone.
Unsaturated zone dry bulk density	g/cm^3	P	1.52	For deterministic run, base value selected is the mean from the distribution. For probabilistic run, distribution from NUREG/CR-6697 is used.	Truncated normal	1.52	0.23	0.001	0.999	See contaminated zone dry bulk density parameter.
Unsaturated zone total porosity	—	P	0.425	For deterministic run, base value selected is the mean from the distribution. For probabilistic run, distribution from NUREG/CR-6697 is used.	Truncated normal	0.425	.0867	0.001	0.999	See clean cover total porosity parameter.

[a] For truncated lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution, parameter 3 = lower quantile, and parameter 4 = upper quantile; for lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution; for triangular distribution, parameter 1 = minimum, parameter 2 = mode or most likely, and parameter 3 = maximum; for truncated normal distribution, parameter 1 = mean, parameter 2 = standard deviation, parameter 3 = lower quantile, and parameter 4 = upper quantile; for bounded lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution, parameter 3 = minimum value, and parameter 4 = maximum value; for uniform distribution, , parameter 1 = minimum, and parameter 2 = maximum; for continuous linear distribution, number of points, value of points, and CDF of points; for continuous logarithmic distribution, number of points, value of points, and CDF of points.
[b] P = physical, B = behavioral, and M = metabolic parameter.
[c] NA = not applicable.
[d] NR = not required.

Table B-42 Base Values and Statistical Distributions of Input Parameters Used in the RESRAD-OFFSITE Code for the Offsite Resident via Water Transport Scenario (cont.)

Input screen title/parameter	Units	Type[b]	Base value for deterministic calculation	Source	Probabilistic analysis[a]					Description
					Distribution	Parameter 1	Parameter 2	Parameter 3	Parameter 4	
Unsaturated Zone Hydrology (cont.)										
Unsaturated zone effective porosity	—	P	0.355	For deterministic run, base value selected is the mean from the distribution. For probabilistic run, distribution from NUREG/ CR-6697 is used.	Truncated normal	0.355	0.0906	0.001	0.999	The effective porosity of the unsaturated zone is the ratio of the pore volume where water can circulate to the total volume of the unsaturated zone. Used along with other hydrological parameters to calculate the water transport breakthrough times.
Unsaturated zone field capacity	—	P	0.3	Code default	None	NR	NR	NR	NR	See contaminated zone field capacity parameter.
Unsaturated zone hydraulic conductivity	m/yr	P	10	Code default	Bounded lognormal-N	2.3	2.11	0.004	9250	See contaminated zone hydraulic conductivity parameter.
Unsaturated zone soil b parameter	—	P	5.3	For deterministic run base value selected is the code default. For probabilistic run, distribution from NUREG/ CR-6697 is used.	Bounded lognormal-N	1.06	0.66	0.5	30	See contaminated zone soil b parameter.
Unsaturated zone longitudinal dispersivity	m	P	0.1	For deterministic run, base value selected is the code default. For probabilistic run, distribution from Yu et al. 2007 is used.	Continuous linear					The ratio between the longitudinal dispersion coefficient and pore water velocity. This parameter is dependent on the thickness of the zone.

[a] For truncated lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution, parameter 3 = lower quantile, and parameter 4 = upper quantile; for lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution; for triangular distribution, parameter 1 = minimum, parameter 2 = mode or most likely, and parameter 3 = maximum; for truncated normal distribution, parameter 1 = mean, parameter 2 = standard deviation, parameter 3 = lower quantile, and parameter 4 = upper quantile; for bounded lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution, parameter 3 = minimum value, and parameter 4 = maximum value; for uniform distribution, , parameter 1 = minimum, and parameter 2 = maximum; for continuous linear distribution, number of points, value of points, and CDF of points; for continuous logarithmic distribution, number of points, value of points, and CDF of points.

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[c] NA = not applicable.

[d] NR = not required.

Table B-42 Base Values and Statistical Distributions of Input Parameters Used in the RESRAD-OFFSITE Code for the Offsite Resident via Water Transport Scenario (cont.)

Input screen title/parameter	Units	Type[b]	Base value for deterministic calculation	Source	Probabilistic analysis[a]					Description
					Distribution	Parameter 1	Parameter 2	Parameter 3	Parameter 4	
Saturated zone hydrology										
Thickness of saturated zone	m	P	100	For deterministic run code default and for probabilistic run uniform distribution from half the default to double the default value.	Uniform	50	200			The thickness of the saturated zone. It is used to model dispersion in the saturated zone in the vertical direction.
Dry bulk density of saturated zone	g/cm^3	P	1.52	For deterministic run, base value selected is the mean from the distribution. For probabilistic run, distribution from NUREG/CR-6697 is used.	Truncated normal	1.52	0.23	0.001	0.999	See contaminated zone dry bulk density parameter.
Saturated zone total porosity	—	P	0.425	For deterministic run, base value selected is the mean from the distribution. For probabilistic run, distribution from NUREG/CR-6697 is used.	Truncated normal	0.425	.0867	0.001	0.999	See clean cover total porosity parameter.

[a] For truncated lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution, parameter 3 = lower quantile, and parameter 4 = upper quantile; for lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution; for triangular distribution, parameter 1 = minimum, parameter 2 = mode or most likely, and parameter 3 = maximum; for truncated normal distribution, parameter 1 = mean, parameter 2 = standard deviation, parameter 3 = lower quantile, and parameter 4 = upper quantile; for bounded lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution, parameter 3 = minimum value, and parameter 4 = maximum value; for uniform distribution, , parameter 1 = minimum, and parameter 2 = maximum; for continuous linear distribution, number of points, value of points, and CDF of points; for continuous logarithmic distribution, number of points, value of points, and CDF of points.

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[c] NA = not applicable.

[d] NR = not required.

Table B-42 Base Values and Statistical Distributions of Input Parameters Used in the RESRAD-OFFSITE Code for the Offsite Resident via Water Transport Scenario (cont.)

Input screen title/parameter	Units	Type[b]	Base value for deterministic calculation	Source	Probabilistic analysis[a] Distribution	Parameter 1	Parameter 2	Parameter 3	Parameter 4	Description
Saturated zone hydrology (cont.)										
Saturated zone effective porosity	—	P	0.355	For deterministic run, base value selected is the mean from the distribution. For probabilistic run, distribution from NUREG/CR-6697 is used.	Truncated normal	0.355	0.0906	0.001	0.999	See unsaturated zone effective porosity parameter.
Saturated zone hydraulic conductivity	m/yr	P	81	For deterministic run, base value selected is the mean from the distribution. For probabilistic run, distribution from NUREG/CR-6697 is used.	Bounded lognormal-N	2.3	2.11	0.004	9250	See contaminated zone hydraulic conductivity parameter.
Saturated zone hydraulic gradient to well	—	P	0.02	For deterministic run, base value selected is the code default. For probabilistic run, distribution from NUREG/CR-6697 is used.	Bounded lognormal-N	-5.11	1.77	0.00007	0.5	The slope of the surface of the water table. The hydraulic gradient is one of several hydrogeological parameters used in water transport calculations.

[a] For truncated lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution, parameter 3 = lower quantile, and parameter 4 = upper quantile; for lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution; for triangular distribution, parameter 1 = minimum, parameter 2 = mode or most likely, and parameter 3 = maximum; for truncated normal distribution, parameter 1 = mean, parameter 2 = standard deviation, parameter 3 = lower quantile, and parameter 4 = upper quantile; for bounded lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution, parameter 3 = minimum value, and parameter 4 = maximum value; for uniform distribution, , parameter 1 = minimum, and parameter 2 = maximum; for continuous linear distribution, number of points, value of points, and CDF of points; for continuous logarithmic distribution, number of points, value of points, and CDF of points.

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[c] NA = not applicable.

[d] NR = not required.

Table B-42 Base Values and Statistical Distributions of Input Parameters Used in the RESRAD-OFFSITE Code for the Offsite Resident via Water Transport Scenario (cont.)

Input screen title/parameter	Units	Type[b]	Base value for deterministic calculation	Source	Probabilistic analysis[a]					Description
					Distribution	Parameter 1	Parameter 2	Parameter 3	Parameter 4	
Saturated zone hydrology (cont.)										
Depth of aquifer contributing to well	m	P	10	For deterministic run, base value selected is the code default. For probabilistic run, distribution from NUREG/CR-6697 is used.	Triangular	6	10	30		The well is assumed to be fully screened from the water table to the specified well screen depth.
Saturated zone longitudinal dispersivity to well	m	P	3	For deterministic run, base value selected is the code default. For probabilistic run, distribution from Yu et al. 2007 is used.	Continuous linear					See unsaturated zone longitudinal dispersivity parameter.
Saturated zone horizontal lateral dispersivity to well	m	P	0.4	For deterministic run, base value selected is the code default. For probabilistic run, distribution from Yu et al. 2007 is used.	Continuous linear					The ratio between the horizontal lateral dispersion coefficient and pore water velocity. This parameter is usually about a tenth to three tenths of the longitudinal dispersivity.

[a] For truncated lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution, parameter 3 = lower quantile, and parameter 4 = upper quantile; for lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution; for triangular distribution, parameter 1 = minimum, parameter 2 = mode or most likely, and parameter 3 = maximum; for truncated normal distribution, parameter 1 = mean, parameter 2 = standard deviation, parameter 3 = lower quantile, and parameter 4 = upper quantile; for bounded lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution, parameter 3 = minimum value, and parameter 4 = maximum value; for uniform distribution, , parameter 1 = minimum, and parameter 2 = maximum; for continuous linear distribution, number of points, value of points, and CDF of points; for continuous logarithmic distribution, number of points, value of points, and CDF of points.

[b] P = physical, B = behavioral, and M = metabolic parameter.

[c] NA = not applicable.

[d] NR = not required.

Table B-42 Base Values and Statistical Distributions of Input Parameters Used in the RESRAD-OFFSITE Code for the Offsite Resident via Water Transport Scenario (cont.)

Input screen title/parameter	Units	Type[b]	Base value for deterministic calculation	Source	Probabilistic analysis[a]					Description
					Distribution	Parameter 1	Parameter 2	Parameter 3	Parameter 4	
Saturated zone hydrology (cont.)										
Saturated zone vertical lateral dispersivity to well	m	P	0.02	For deterministic run, base value selected is the code default. For probabilistic run, distribution from Yu et al. 2007 is used.	Continuous linear					The ratio between the vertical lateral dispersion coefficient and pore water velocity.
Saturated zone hydraulic gradient to surface water body	—	P	0.02	For deterministic run, base value selected is the code default. For probabilistic run, distribution from NUREG/CR-6697 is used.	Bounded lognormal-N	-5.11	1.77	0.00007	0.5	The slope of the surface of the water table. The hydraulic gradient is one of several hydrogeological parameters used in water transport calculations.
Depth of aquifer contributing to surface water body	m	P	10	For deterministic run, base value selected is the code default. For probabilistic run, distribution from NUREG/CR-6697 is used.	Uniform	5	20			The depth of the aquifer that flows into the surface water body. If water flows in the opposite direction (from the surface water body into the aquifer) this depth would be zero. This depth calculates the contaminant flux reaching the surface water body by way of the aquifer.

[a] For truncated lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution, parameter 3 = lower quantile, and parameter 4 = upper quantile; for lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution; for triangular distribution, parameter 1 = minimum, parameter 2 = mode or most likely, and parameter 3 = maximum; for truncated normal distribution, parameter 1 = mean, parameter 2 = standard deviation, parameter 3 = lower quantile, and parameter 4 = upper quantile; for bounded lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution, parameter 3 = minimum value, and parameter 4 = maximum value; for uniform distribution, , parameter 1 = minimum, and parameter 2 = maximum; for continuous linear distribution, number of points, value of points, and CDF of points; for continuous logarithmic distribution, number of points, value of points, and CDF of points.

[b] P = physical, B = behavioral, and M = metabolic parameter.

[c] NA = not applicable.

[d] NR = not required.

Table B-42 Base Values and Statistical Distributions of Input Parameters Used in the RESRAD-OFFSITE Code for the Offsite Resident via Water Transport Scenario (cont.)

Input screen title/parameter	Units	Type[b]	Base value for deterministic calculation	Source	Probabilistic analysis[a] Distribution	Parameter 1	Parameter 2	Parameter 3	Parameter 4	Description
Saturated zone hydrology (cont.)										
Saturated zone longitudinal dispersivity to surface water body	m	P	10	For deterministic run, base value selected is the code default. For probabilistic run, distribution from Yu et al. 2007 is used.	Continuous linear					See unsaturated zone longitudinal dispersivity parameter.
Saturated zone horizontal lateral dispersivity to surface water body	m	P	1	For deterministic run, base value selected is the code default. For probabilistic run, distribution from Yu et al. 2007 is used.	Continuous linear					The ratio between the horizontal lateral dispersion coefficient and pore water velocity. This parameter is usually about a tenth to three tenths of the longitudinal dispersivity.
Saturated zone vertical lateral dispersivity to surface water body	m	P	0.06	For deterministic run, base value selected is the code default. For probabilistic run, distribution from Yu et al. 2007 is used.	Continuous linear					The ratio between the vertical lateral dispersion coefficient and pore water velocity.
Water use										
Consumption by humans										
Quantity of water consumed by an individual	l/yr	M, B	510	Code default	NR	NR	NR	NR	NR	The total amount of water consumed by an individual; it includes water used in the preparation of and consumed with food.
Fraction of water from surface body for consumption by humans	—	B, P	0.5	Assumption	NR	NR	NR	NR	NR	The fraction of water consumed by humans obtained from the surface water source.

[a] For truncated lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution, parameter 3 = lower quantile, and parameter 4 = upper quantile; for lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution; for triangular distribution, parameter 1 = minimum, parameter 2 = mode or most likely, and parameter 3 = maximum; for truncated normal distribution, parameter 1 = mean, parameter 2 = standard deviation, parameter 3 = lower quantile, and parameter 4 = upper quantile; for bounded lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution, parameter 3 = minimum value, and parameter 4 = maximum value; for uniform distribution, , parameter 1 = minimum, and parameter 2 = maximum; for continuous linear distribution, number of points, value of points, and CDF of points; for continuous logarithmic distribution, number of points, value of points, and CDF of points.

[b] P = physical, B = behavioral, and M = metabolic parameter.

[c] NA = not applicable.

[d] NR = not required.

Table B-42 Base Values and Statistical Distributions of Input Parameters Used in the RESRAD-OFFSITE Code for the Offsite Resident via Water Transport Scenario (cont.)

Input screen title/parameter	Units	Type[b]	Base value for deterministic calculation	Source	Probabilistic analysis[a] Distribution	Parameter 1	Parameter 2	Parameter 3	Parameter 4	Description
Water use (cont.)										
Consumption by humans (cont.)										
Fraction of water from well for consumption by humans	—	B, P	0.5	Assumption	NR	NR	NR	NR	NR	The fraction of water consumed by humans obtained from the well.
Number of household individuals consuming and using water	—	B	4	Code default	NR	NR	NR	NR	NR	Number of household individuals for calculating water use.
Use indoors of dwelling										
Quantity of water for use indoors of dwelling per individual	l/yr	M, B	225	Code default	NR	NR	NR	NR	NR	The total amount of water used indoors by an individual for bathing, laundry, washing, etc. This quantity is used to estimate the volume of water that needs to be extracted from the well to satisfy the specified needs.
Fraction of water from surface body for use indoors of dwelling	—	B, P	0.5	Assumption	NR	NR	NR	NR	NR	The fraction of water used in the dwelling obtained from the surface water source. This factor is used in the computation of indoor radon.
Fraction of water from well for use indoors of dwelling	—	B, P	0.5	Assumption	NR	NR	NR	NR	NR	The fraction of water used in the dwelling obtained from the well. This factor is used in the computation of indoor radon
Number of household individuals for household purposes	—	B	4	Code default	NR	NR	NR	NR	NR	Number of household individuals for calculating water use.
Beef cattle										
Quantity of water for beef cattle	L/yr	M	50	Code default	NR	NR	NR	NR	NR	The daily intake of water by beef cattle kept for meat production.
Fraction of water from surface body for beef cattle	—	B, P	0.5	Assumption	NR	NR	NR	NR	NR	The fraction of water consumed by beef cattle raised for meat obtained from the surface water source.
Fraction of water from well for beef cattle	—	B, P	0.5	Assumption	NR	NR	NR	NR	NR	The fraction of water consumed by beef cattle raised for meat obtained from the well water source.
Number of cattle for beef cattle	—	B	2	Code default	NR	NR	NR	NR	NR	Number of beef cattle for calculating water use.
Dairy cows										
Quantity of water for dairy cows	L/yr	M	160	Code default	NR	NR	NR	NR	NR	The daily intake of water by dairy cows kept for milk production.

[a] For truncated lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution, parameter 3 = lower quantile, and parameter 4 = upper quantile; for lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution; for triangular distribution, parameter 1 = minimum, parameter 2 = mode or most likely, and parameter 3 = maximum; for truncated normal distribution, parameter 1 = mean, parameter 2 = standard deviation, parameter 3 = lower quantile, and parameter 4 = upper quantile; for bounded lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution, parameter 3 = minimum value, and parameter 4 = maximum value; for uniform distribution, , parameter 1 = minimum, and parameter 2 = maximum; for continuous linear distribution, number of points, value of points, and CDF of points; for continuous logarithmic distribution, number of points, value of points, and CDF of points.

[b] P = physical, B = behavioral, and M = metabolic parameter.

[c] NA = not applicable.

[d] NR = not required.

Table B-42 Base Values and Statistical Distributions of Input Parameters Used in the RESRAD-OFFSITE Code for the Offsite Resident via Water Transport Scenario (cont.)

Input screen title/parameter	Units	Type[b]	Base value for deterministic calculation	Source	Probabilistic analysis[a]					Description
					Distribution	Parameter 1	Parameter 2	Parameter 3	Parameter 4	
Water use (cont.)										
Dairy cows (cont.)										
Fraction of water from surface body for dairy cows	—	B, P	0.5	Assumption	NR	NR	NR	NR	NR	The fraction of water consumed by dairy cows raised for milk obtained from the surface water source.
Fraction of water from well for dairy cows	—	B, P	0.5	Assumption	NR	NR	NR	NR	NR	The fraction of water consumed by dairy cows raised for milk obtained from the well water source.
Number of dairy cows	—	B	2	Code default	NR	NR	NR	NR	NR	Number of dairy cows for calculating water use.
Fruit, grain, non-leafy vegetables										
Quantity of irrigation for fruit, grain, and non-leafy vegetables	m/yr	B	0.2	For deterministic run, base value selected is the code default. For probabilistic run, the minimum being 1/2 of the base value, and the maximum being two times the base value.	Uniform	0.1	0.4	NR	NR	The amount of irrigation applied on an area used to produce leafy vegetables.
Fraction of water from surface body for fruit, grain, and non-leafy vegetables	—	B, P	0.5	Assumption	NR	NR	NR	NR	NR	The fraction of irrigation water applied at fruit, grain, and non-leafy vegetable field obtained from the surface water source.
Fraction of water from well for fruit, grain, and non-leafy vegetables	—	B, P	0.5	Assumption	NR	NR	NR	NR	NR	The fraction of irrigation water applied at fruit, grain, and non-leafy vegetable field obtained from the well.
Area of plot for fruit, grain, and non-leafy vegetables	m^2	B	1000 (calculated from parameters in Site Layout Form)							The area of the plot used to produce fruit, grain, and non-leafy vegetables where irrigation is applied.

[a] For truncated lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution, parameter 3 = lower quantile, and parameter 4 = upper quantile; for lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution; for triangular distribution, parameter 1 = minimum, parameter 2 = mode or most likely, and parameter 3 = maximum; for truncated normal distribution, parameter 1 = mean, parameter 2 = standard deviation, parameter 3 = lower quantile, and parameter 4 = upper quantile; for bounded lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution, parameter 3 = minimum value, and parameter 4 = maximum value; for uniform distribution, , parameter 1 = minimum, and parameter 2 = maximum; for continuous linear distribution, number of points, value of points, and CDF of points; for continuous logarithmic distribution, number of points, value of points, and CDF of points.

[b] P = physical, B = behavioral, and M = metabolic parameter.

[c] NA = not applicable.

[d] NR = not required.

Table B-42 Base Values and Statistical Distributions of Input Parameters Used in the RESRAD-OFFSITE Code for the Offsite Resident via Water Transport Scenario (cont.)

Input screen title/parameter	Units	Type[b]	Base value for deterministic calculation	Source	Probabilistic analysis[a]					Description
					Distribution	Parameter 1	Parameter 2	Parameter 3	Parameter 4	
Water use (cont.)										
Leafy vegetables										
Quantity of irrigation for leafy vegetables	m/yr	B	0.2	For deterministic run, base value selected is the code default. For probabilistic run, the minimum being 1/2 of the base value, and the maximum being two times the base value.	Uniform	0.1	0.4	NR	NR	The amount of irrigation applied on an area used to produce leafy vegetables.
Fraction of water from surface body for leafy vegetables	—	B, P	0.5	Assumption	NR	NR	NR	NR	NR	The fraction of irrigation water applied at leafy vegetable field obtained from the surface water source.
Fraction of water from well for leafy vegetables	—	B, P	0.5	Assumption	NR	NR	NR	NR	NR	The fraction of irrigation water applied at leafy vegetable field obtained from the well.
Area of plot for leafy vegetables	m^2	B	1000 (calculated from parameters in Site Layout Form)							The area of the plot used to produce leafy vegetables where irrigation is applied.
Pasture, silage										
Quantity of irrigation for pasture and silage	m/yr	B	0.2	For deterministic run, base value selected is the code default For probabilistic run, the minimum being 1/2 of the base value, and the maximum being two times the base value.	Uniform	0.1	0.4	NR	NR	The amount of irrigation applied on an area used to produce pasture and silage.

[a] For truncated lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution, parameter 3 = lower quantile, and parameter 4 = upper quantile; for lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution; for triangular distribution, parameter 1 = minimum, parameter 2 = mode or most likely, and parameter 3 = maximum; for truncated normal distribution, parameter 1 = mean, parameter 2 = standard deviation, parameter 3 = lower quantile, and parameter 4 = upper quantile; for bounded lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution, parameter 3 = minimum value, and parameter 4 = maximum value; for uniform distribution, , parameter 1 = minimum, and parameter 2 = maximum; for continuous linear distribution, number of points, value of points, and CDF of points; for continuous logarithmic distribution, number of points, value of points, and CDF of points.

[b] P = physical, B = behavioral, and M = metabolic parameter.

[c] NA = not applicable.

[d] NR = not required.

Table B-42 Base Values and Statistical Distributions of Input Parameters Used in the RESRAD-OFFSITE Code for the Offsite Resident via Water Transport Scenario (cont.)

Input screen title/parameter	Units	Type[b]	Base value for deterministic calculation	Source	Probabilistic analysis[a] Distribution	Parameter 1	Parameter 2	Parameter 3	Parameter 4	Description
Water use (cont.)										
Pasture, silage (cont.)										
Quantity of irrigation for pasture and silage	m/yr	B	0.2	For deterministic run, base value selected is the code default For probabilistic run, the minimum being 1/2 of the base value, and the maximum being two times the base value.	Uniform	0.1	0.4	NR	NR	The amount of irrigation applied on an area used to produce pasture and silage.
Fraction of water from surface body for pasture and silage	—	B, P	0.5	Assumption	NR	NR	NR	NR	NR	The fraction of irrigation water applied at pasture and silage field obtained from the surface water source.
Fraction of water from well for pasture and silage	—	B, P	0.5	Assumption	NR	NR	NR	NR	NR	The fraction of irrigation water applied at pasture and silage field obtained from the well.
Area of plot for pasture and silage	m^2	B	10000 (calculated from parameters in Site Layout Form)							The area of the plot used to produce pasture and silage where irrigation is applied.

[a] For truncated lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution, parameter 3 = lower quantile, and parameter 4 = upper quantile; for lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution; for triangular distribution, parameter 1 = minimum, parameter 2 = mode or most likely, and parameter 3 = maximum; for truncated normal distribution, parameter 1 = mean, parameter 2 = standard deviation, parameter 3 = lower quantile, and parameter 4 = upper quantile; for bounded lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution, parameter 3 = minimum value, and parameter 4 = maximum value; for uniform distribution, , parameter 1 = minimum, and parameter 2 = maximum; for continuous linear distribution, number of points, value of points, and CDF of points; for continuous logarithmic distribution, number of points, value of points, and CDF of points.

[b] P = physical, B = behavioral, and M = metabolic parameter.

[c] NA = not applicable.

[d] NR = not required.

Table B-42 Base Values and Statistical Distributions of Input Parameters Used in the RESRAD-OFFSITE Code for the Offsite Resident via Water Transport Scenario (cont.)

Input screen title/parameter	Units	Type[b]	Base value for deterministic calculation	Source	Probabilistic analysis[a]					Description
					Distribution	Parameter 1	Parameter 2	Parameter 3	Parameter 4	
Water use (cont.)										
Livestock feed grain										
Quantity of irrigation for livestock feed grain	m/yr	B	0.2	For deterministic run, base value selected is the code default. For probabilistic run, the minimum being 1/2 of the base value, and the maximum being two times the base value.	Uniform	0.1	0.4	NR	NR	The amount of irrigation applied on an area used to produce livestock feed grain.
Fraction of water from surface body for livestock feed grain	—	B, P	0.5	Assumption	NR	NR	NR	NR	NR	The fraction of irrigation water applied at livestock feed grain field obtained from the surface water source.
Fraction of water from well for livestock feed grain	—	B, P	0.5	Assumption	NR	NR	NR	NR	NR	The fraction of irrigation water applied at livestock feed grain field obtained from the well.
Area of plot for livestock feed grain	m^2	B	10000 (calculated from parameters in Site Layout Form)							The area of the plot used to produce livestock feed grain where irrigation is applied.

[a] For truncated lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution, parameter 3 = lower quantile, and parameter 4 = upper quantile; for lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution; for triangular distribution, parameter 1 = minimum, parameter 2 = mode or most likely, and parameter 3 = maximum; for truncated normal distribution, parameter 1 = mean, parameter 2 = standard deviation, parameter 3 = lower quantile, and parameter 4 = upper quantile; for bounded lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution, parameter 3 = minimum value, and parameter 4 = maximum value; for uniform distribution, , parameter 1 = minimum, and parameter 2 = maximum; for continuous linear distribution, number of points, value of points, and CDF of points; for continuous logarithmic distribution, number of points, value of points, and CDF of points.

[b] P = physical, B = behavioral, and M = metabolic parameter.

[c] NA = not applicable.

[d] NR = not required.

Table B-42 Base Values and Statistical Distributions of Input Parameters Used in the RESRAD-OFFSITE Code for the Offsite Resident via Water Transport Scenario (cont.)

Input screen title/parameter	Units	Type[b]	Base value for deterministic calculation	Source	Probabilistic analysis[a]					Description
					Distribution	Parameter 1	Parameter 2	Parameter 3	Parameter 4	
Water use (cont.)										
Offsite dwelling site										
Quantity of irrigation for offsite dwelling site	m/yr	B	0.2	For deterministic run, base value selected is the code default. For probabilistic run, the minimum being 1/2 of the base value, and the maximum being two times the base value.	Uniform	0.1	0.4	NR	NR	The amount of irrigation applied on an area used for offsite dwelling site.
Fraction of water from surface body for offsite dwelling site	—	B, P	0.5	Assumption	NR	NR	NR	NR	NR	The fraction of irrigation water applied at offsite dwelling site obtained from the surface water source.
Fraction of water from well for offsite dwelling site	—	B, P	0.5	Assumption	NR	NR	NR	NR	NR	The fraction of irrigation water applied offsite dwelling site obtained from the well.
Area of plot for offsite dwelling site	m^2	B	1000 (calculated from parameters in Site Layout Form)							The area of the plot used for offsite dwelling site where irrigation is applied.

[a] For truncated lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution, parameter 3 = lower quantile, and parameter 4 = upper quantile; for lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution; for triangular distribution, parameter 1 = minimum, parameter 2 = mode or most likely, and parameter 3 = maximum; for truncated normal distribution, parameter 1 = mean, parameter 2 = standard deviation, parameter 3 = lower quantile, and parameter 4 = upper quantile; for bounded lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution, parameter 3 = minimum value, and parameter 4 = maximum value; for uniform distribution, , parameter 1 = minimum, and parameter 2 = maximum; for continuous linear distribution, number of points, value of points, and CDF of points; for continuous logarithmic distribution, number of points, value of points, and CDF of points.

[b] P = physical, B = behavioral, and M = metabolic parameter.

[c] NA = not applicable.

[d] NR = not required.

Table B-42 Base Values and Statistical Distributions of Input Parameters Used in the RESRAD-OFFSITE Code for the Offsite Resident via Water Transport Scenario (cont.)

Input screen title/parameter	Units	Type[b]	Base value for deterministic calculation	Source	Probabilistic analysis[a]					Description
					Distribution	Parameter 1	Parameter 2	Parameter 3	Parameter 4	
Water use (cont.)										
Offsite dwelling site (cont.)										
Well pumping rate	m^3/yr	B, P	5100	For deterministic run, base value selected is the code default. For probabilistic run, the minimum value is 50 percent lower than the base value and the maximum value is 50 percent higher than the base value.	Uniform	2550	7650			The total volume of water withdrawn from the well for all purposes. Used to estimate the dilution that occurs in the well.
Well pumping rate needed to support specified water use for livestock feed grain	m^3/yr	B, P	2542.1							Calculated
Surface water body										
Surface area of water in surface water body	m^2	NA	90,000							Calculated value from the site coordinated in the Site Layout form.
Volume of surface water body	m^3	P	150,000	For deterministic run, base value selected is the code default. For probabilistic run, uniform distribution from half to double the default value is used.	Uniform	75,000	300,000			The volume of water in a surface water body.

[a] For truncated lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution, parameter 3 = lower quantile, and parameter 4 = upper quantile; for lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution; for triangular distribution, parameter 1 = minimum, parameter 2 = mode or most likely, and parameter 3 = maximum; for truncated normal distribution, parameter 1 = mean, parameter 2 = standard deviation, parameter 3 = lower quantile, and parameter 4 = upper quantile; for bounded lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution, parameter 3 = minimum value, and parameter 4 = maximum value; for uniform distribution, , parameter 1 = minimum, and parameter 2 = maximum; for continuous linear distribution, number of points, value of points, and CDF of points; for continuous logarithmic distribution, number of points, value of points, and CDF of points.

[b] P = physical, B = behavioral, and M = metabolic parameter.

[c] NA = not applicable.

[d] NR = not required.

Table B-42 Base Values and Statistical Distributions of Input Parameters Used in the RESRAD-OFFSITE Code for the Offsite Resident via Water Transport Scenario (cont.)

Input screen title/parameter	Units	Type[b]	Base value for deterministic calculation	Source	Probabilistic analysis[a]					Description
					Distribution	Parameter 1	Parameter 2	Parameter 3	Parameter 4	
Water use (cont.)										
Surface water body										
Potential evaporation	m/yr	P	1	For deterministic run, base value selected is the code default. For probabilistic run, uniform distribution from 0.25 to default value is used.	0.25	1				
Stream outflow (as a fraction of total outflow)		NA	0.9934 (calculated from inflow)							Calculated value from other parameters
Settling velocity of sediments	cm/s	P	0.1	For deterministic run, base value selected is the code default. For probabilistic run, uniform distribution from 1/2 to twice the base value.	Uniform	0.05	0.2			
Density of bottom sediment	g/cm3	P	1.5	For deterministic run, base value selected is the code default. For probabilistic run, uniform distribution from +/- 33 percent from base value.	Uniform	1	2			

[a] For truncated lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution, parameter 3 = lower quantile, and parameter 4 = upper quantile; for lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution; for triangular distribution, parameter 1 = minimum, parameter 2 = mode or most likely, and parameter 3 = maximum; for truncated normal distribution, parameter 1 = mean, parameter 2 = standard deviation, parameter 3 = lower quantile, and parameter 4 = upper quantile; for bounded lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution, parameter 3 = minimum value, and parameter 4 = maximum value; for uniform distribution, , parameter 1 = minimum, and parameter 2 = maximum; for continuous linear distribution, number of points, value of points, and CDF of points; for continuous logarithmic distribution, number of points, value of points, and CDF of points.

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[c] NA = not applicable.

[d] NR = not required.

Table B-42 Base Values and Statistical Distributions of Input Parameters Used in the RESRAD-OFFSITE Code for the Offsite Resident via Water Transport Scenario (cont.)

Input screen title/parameter	Units	Type[b]	Base value for deterministic calculation	Source	Probabilistic analysis[a]					Description
					Distribution	Parameter 1	Parameter 2	Parameter 3	Parameter 4	
Water use (cont.)										
Surface water body (cont.)										
Thickness of bottom sediment layer in adsorption/desorption equilibrium of radionuclides with water	m	P	0.05	For deterministic run, base value selected is the code default. For probabilistic run, uniform distribution from 1/2 to twice the base value.	Uniform	0.025	0.1			The radionuclides in the older sediment that is buried below the more recent sediment will not have the opportunity to be in equilibrium with the water in the surface water body. This is the thickness of the top layer of the sediment that is considered for the adsorption-desorption equilibrium of the radionuclide with that in the water.
Sediment from primary contamination delivery ratio	—	P	1	For deterministic run, base value selected is the code default. For probabilistic run, uniform distribution from 1/2 to the base value.	Uniform	0.5	1			The fraction of the contaminated soil that was eroded from the area of primary contamination that reaches the surface water body.
Number of catchment areas	—	P	1	Assumption	NR	NR	NR	NR	NR	Only one catchment area contributes to surface water body.
Catchment areas characteristics										
Smaller X coordinate	m	P	-1450	Assumption	NR	NR	NR	NR		
Larger X coordinate	m	P	1550	Assumption	NR	NR	NR	NR		
Smaller Y coordinate	m	P	-2450	Assumption	NR	NR	NR	NR		
Larger Y coordinate	m	P	550	Assumption	NR	NR	NR	NR		
Surface area	m^2		9E6 (calculated from catchment area X and Y coordinates)							Calculated

[a] For truncated lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution, parameter 3 = lower quantile, and parameter 4 = upper quantile; for lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution; for triangular distribution, parameter 1 = minimum, parameter 2 = mode or most likely, and parameter 3 = maximum; for truncated normal distribution, parameter 1 = mean, parameter 2 = standard deviation, parameter 3 = lower quantile, and parameter 4 = upper quantile; for bounded lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution, parameter 3 = minimum value, and parameter 4 = maximum value; for uniform distribution, , parameter 1 = minimum, and parameter 2 = maximum; for continuous linear distribution, number of points, value of points, and CDF of points; for continuous logarithmic distribution, number of points, value of points, and CDF of points.

[b] P = physical, B = behavioral, and M = metabolic parameter.

[c] NA = not applicable.

[d] NR = not required.

Table B-42 Base Values and Statistical Distributions of Input Parameters Used in the RESRAD-OFFSITE Code for the Offsite Resident via Water Transport Scenario (cont.)

Input screen title/parameter	Units	Type[b]	Base value for deterministic calculation	Source	Probabilistic analysis[a] Distribution	Parameter 1	Parameter 2	Parameter 3	Parameter 4	Description
Water use (cont.)										
Catchment areas characteristics (cont.)										
Runoff coefficient	—	P	0.2	For deterministic run, base value selected is the code default. For probabilistic run, distribution from NUREG/CR-6697 is used.	Uniform	0.1	0.8			See primary contamination runoff coefficient
Soil erodibility factor	Tons/acre	P	0.4	For deterministic run, base value selected is the code default. For probabilistic run, distribution from Yu et al. 2007 is used.	Continuous linear					See contaminated zone soil erodibility factor
Slope-length-steepness factor	—	P	0.4	For deterministic run, base value selected is the code default. For probabilistic run, distribution from Yu et al. 2007 is used.	Continuous linear					See primary contamination slope-length-steepness factor

[a] For truncated lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution, parameter 3 = lower quantile, and parameter 4 = upper quantile; for lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution; for triangular distribution, parameter 1 = minimum, parameter 2 = mode or most likely, and parameter 3 = maximum; for truncated normal distribution, parameter 1 = mean, parameter 2 = standard deviation, parameter 3 = lower quantile, and parameter 4 = upper quantile; for bounded lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution, parameter 3 = minimum value, and parameter 4 = maximum value; for uniform distribution, , parameter 1 = minimum, and parameter 2 = maximum; for continuous linear distribution, number of points, value of points, and CDF of points; for continuous logarithmic distribution, number of points, value of points, and CDF of points.

[b] P = physical, B = behavioral, and M = metabolic parameter.

[c] NA = not applicable.

[d] NR = not required.

Table B-42 Base Values and Statistical Distributions of Input Parameters Used in the RESRAD-OFFSITE Code for the Offsite Resident via Water Transport Scenario (cont.)

Input screen title/parameter	Units	Type[b]	Base value for deterministic calculation	Source	Probabilistic analysis[a] Distribution	Parameter 1	Parameter 2	Parameter 3	Parameter 4	Description
Water use (cont.)										
Catchment areas characteristics (cont.)										
Cover and management factor	—	P	0.003	For deterministic run, base value selected is the code default. For probabilistic run, distribution from Yu et al. 2007 is used.	Continuous linear					See primary contamination cover and management factor
Support practice factor	—	P	1	For deterministic run, base value selected is the code default. For probabilistic run, distribution from Yu et al. 2007 is used.	Continuous linear					See primary contamination slope-length-steepness factor
Sediment delivery ratio	—	P	0.21 (estimated using catchment area)							This is the fraction of the soil that was eroded from the catchment that reaches the surface water body
Fraction of deposited radionuclide reaching surface water body			0.02	For deterministic run, base value selected is the code default. For probabilistic run, uniform distribution from 1/2 to twice the base value	Uniform	0.01	0.04			Fraction of deposited radionuclides reaching surface water body is modeled either by atmospheric deposition on catchment or approximated by atmospheric release

[a] For truncated lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution, parameter 3 = lower quantile, and parameter 4 = upper quantile; for lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution; for triangular distribution, parameter 1 = minimum, parameter 2 = mode or most likely, and parameter 3 = maximum; for truncated normal distribution, parameter 1 = mean, parameter 2 = standard deviation, parameter 3 = lower quantile, and parameter 4 = upper quantile; for bounded lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution, parameter 3 = minimum value, and parameter 4 = maximum value; for uniform distribution, , parameter 1 = minimum, and parameter 2 = maximum; for continuous linear distribution, number of points, value of points, and CDF of points; for continuous logarithmic distribution, number of points, value of points, and CDF of points.

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[c] NA = not applicable.

[d] NR = not required.

Table B-42 Base Values and Statistical Distributions of Input Parameters Used in the RESRAD-OFFSITE Code for the Offsite Resident via Water Transport Scenario (cont.)

Input screen title/parameter	Units	Type[b]	Base value for deterministic calculation	Source	Probabilistic analysis[a] Distribution	Parameter 1	Parameter 2	Parameter 3	Parameter 4	Description
Water use (cont.)										
Catchment areas characteristics (cont.)										
Model atmospheric deposition on catchment	—	P	Yes	Assumption	NR	NR	NR	NR	NR	The code has two option either model atmospheric deposition on catchment or approximate by atmospheric deposition
Approximate by atmospheric release	—	P	No	Assumption	NR	NR	NR	NR	NR	The code has two option either model atmospheric deposition on catchment or approximate by atmospheric deposition
Convergence criteria for atmospheric deposition			0.001	Assumption	NR	NR	NR	NR	NR	Conversion criteria for the areal integration of the atmospheric transport from the primary contamination to the catchment
Groundwater transport										
Distance in the direction parallel to aquifer flow from downgradient edge of contamination to:										
Well	m	P, B	100	For deterministic run, base value selected is the code default. For probabilistic run, uniform distribution from 1/2 to twice the base value	Uniform	50	200			The distance between two parallel lines that are perpendicular to the direction of aquifer flow, one at the downgradient edge of the contaminated zone and the other at the well.
Surface water body	m	P	450	For deterministic run, base value selected is the code default. For probabilistic run, uniform distribution from 1/2 to twice the base value	Uniform	225	900			This the distance between two parallel lines perpendicular to the direction of aquifer flow, one at the downgradient edge of the contaminated zone and the other at the closest point on the surface water body.

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[b] P = physical, B = behavioral, and M = metabolic parameter.

[c] NA = not applicable.

[d] NR = not required.

Table B-42 Base Values and Statistical Distributions of Input Parameters Used in the RESRAD-OFFSITE Code for the Offsite Resident via Water Transport Scenario (cont.)

Input screen title/parameter	Units	Type[b]	Base value for deterministic calculation	Source	Probabilistic analysis[a]					Description
					Distribution	Parameter 1	Parameter 2	Parameter 3	Parameter 4	
Groundwater transport (cont.)										
Distance in the direction perpendicular to aquifer flow from center of contamination to:										
Well	m	P, B	0	Assumption	NR	NR	NR	NR	NR	This the distance between two parallel lines that are parallel to the direction of aquifer flow, one through the center of the contaminated zone and the other at the well.
Left edge of surface water body	m	P	-150	Assumption	NR	NR	NR	NR	NR	This the distance between two parallel lines that are parallel to the direction of aquifer flow, one through the center of the contaminated zone and the other at the closest point on the surface water body.
Right edge of surface water body	m	P	150	Assumption	NR	NR	NR	NR	NR	This the distance between two parallel lines that are parallel to the direction of aquifer flow, one through the center of the contaminated zone and the other at the farthest point on the surface water body.
Convergence criterion (fractional accuracy desired)	—	P	0.001	Assumption	NR	NR	NR	NR	NR	It is the fractional accuracy desired (convergence criterion) in the Romberg integration used to calculate the contaminant flux or concentration in groundwater.
Number of subzones (to model dispersion of progeny produced in transit)										
Main sub zones in contaminated medium	—	NA	NR	Assumption	NR	NR	NR	NR	NR	
Main sub zones in primary contamination	—	NA	1	Assumption	NR	NR	NR	NR	NR	The primary contaminated zone subdivided into subzones to improve the predictions for the transport of progeny nuclides.
Main sub zones in submerged primary contamination	—	NA	1	Assumption	NR	NR	NR	NR	NR	The submerged primary contamination zone subdivided into subzones to improve the predictions for the transport of progeny nuclides.
Main sub zones in each partially saturated zone	—	NA	1	Assumption	NR	NR	NR	NR	NR	Each partially saturated zone subdivided into subzones to improve the predictions for the transport of progeny nuclides.

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[c] NA = not applicable.

[d] NR = not required.

Table B-42 Base Values and Statistical Distributions of Input Parameters Used in the RESRAD-OFFSITE Code for the Offsite Resident via Water Transport Scenario (cont.)

Input screen title/parameter	Units	Type[b]	Base value for deterministic calculation	Source	Probabilistic analysis[a] Distribution	Parameter 1	Parameter 2	Parameter 3	Parameter 4	Description
Groundwater transport (cont.)										
Number of subzones (to model dispersion of progeny produced in transit) (cont.)										
Main sub zones in saturated zone	—	NA	1	Assumption	NR	NR	NR	NR	NR	The saturated zone subdivided into subzones to improve the predictions for the transport of progeny nuclides.
Retardation and dispersion treatment										
Nuclide-specific retardation in all subzones, longitudinal dispersion in all but the subzone of transformation?	—	NA	Yes	Assumption	NR	NR	NR	NR	NR	When the layer is subdivided one must choose which process, longitudinal dispersion or nuclide-specific retardation, will be considered in the subzone in which each atom undergoes a transformation.
Longitudinal dispersion in all subzones, nuclide-specific retardation in all but the subzone of transformation, parent retardation in zone of transformation?	—	NA	No	Assumption	NR	NR	NR	NR	NR	See above
Longitudinal dispersion in all subzones, nuclide-specific retardation in all but the subzone of transformation, progeny retardation in zone of transformation?	—	NA	No	Assumption	NR	NR	NR	NR	NR	See above
Ingestion rates										
Consumption rate										
Drinking water intake	L/yr	M, B	510	Code default	None	NR	NR	NR	NR	The amount of water consumed by a single individual in a year.
Fish consumption	kg/yr	M, B	5.4	Code default	None	NR	NR	NR	NR	The weight of fish consumed by a single individual in a year.
Other aquatic food consumption	kg/yr	M, B	0.9	Code default	None	NR	NR	NR	NR	The weight of other aquatic organisms consumed by a single individual in a year.
Fruit, grain, non-leafy vegetables consumption	kg/yr	M, B	160	Code default	None	NR	NR	NR	NR	The weight of non-leafy vegetables, fruits, or grain consumed by a single individual in a year.
Leafy vegetables consumption	kg/yr	M, B	14	Code default	None	NR	NR	NR	NR	The weight of leafy vegetables consumed by a single individual in a year.
Meat consumption	kg/yr	M, B	63	Code default	None	NR	NR	NR	NR	The weight of meat consumed by a single individual in a year.
Milk consumption	l/yr	M, B	92	Code default	None	NR	NR	NR	NR	The weight of milk consumed by a single individual in a year.

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[b] P = physical, B = behavioral, and M = metabolic parameter.

[c] NA = not applicable.

[d] NR = not required.

Table B-42 Base Values and Statistical Distributions of Input Parameters Used in the RESRAD-OFFSITE Code for the Offsite Resident via Water Transport Scenario (cont.)

Input screen title/parameter	Units	Type[b]	Base value for deterministic calculation	Source	Probabilistic analysis[a] Distribution	Parameter 1	Parameter 2	Parameter 3	Parameter 4	Description
Ingestion rates (cont.)										
Consumption rate (cont.)										
Soil (incidental) ingestion rate	g/yr	M, B	36.5	Code default	None	NR	NR	NR	NR	The quantity of soil ingested by a single individual in a year.
Fraction from affected area										
Drinking water intake from affected area	—	B, P	1	Code default	None	NR	NR	NR	NR	The fraction of drinking water consumed by an individual obtained from the contaminated area.
Fish consumption from affected area	—	B, P	0.5	Code default	None	NR	NR	NR	NR	The fraction of fish consumed by an individual obtained from the contaminated surface water body.
Other aquatic food consumption from affected area	—	B, P	0.5	Code default	None	NR	NR	NR	NR	The fraction of the other aquatic food consumed by an individual obtained from the contaminated surface water body.
Fruit, grain, non-leafy vegetables consumption from affected area	—	B, P	0.5	Code default	None	NR	NR	NR	NR	The fraction of fruit, non-leafy vegetables, or grain consumed by an individual obtained from contaminated agricultural areas.
Leafy vegetables consumption from affected area	—	B, P	0.5	Code default	None	NR	NR	NR	NR	The fraction of leafy vegetables consumed by an individual obtained from contaminated agricultural areas.
Meat consumption from affected area	—	B, P	1	Code default	None	NR	NR	NR	NR	The fraction of meat consumed by an individual produced using contaminated feed and water.
Milk consumption from affected area	—	B, P	1	Code default	None	NR	NR	NR	NR	The fraction of milk consumed by an individual produced using contaminated feed and water.
Livestock intakes										
Water intake for meat cows	L/d	M	50	Code default	None	NR	NR	NR	NR	The daily intake of water by meat cows kept for meat production.
Pasture and silage intake for meat cows	kg/d	M	14	Code default	None	NR	NR	NR	NR	The daily intake of silage or pasture by meat cows kept for meat production.
Grain intake for meat cows	kg/d	M	54	Code default	None	NR	NR	NR	NR	The daily intake of grain by meat cows kept for meat production.
Soil from pasture and silage intake for meat cows	kg/d	M	0.1	Code default	None	NR	NR	NR	NR	The daily incidental intake of soil with silage or pasture by meat cows kept for meat production.

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[b] P = physical, B = behavioral, and M = metabolic parameter.

[c] NA = not applicable.

[d] NR = not required.

Table B-42 Base Values and Statistical Distributions of Input Parameters Used in the RESRAD-OFFSITE Code for the Offsite Resident via Water Transport Scenario (cont.)

Input screen title/parameter	Units	Type[b]	Base value for deterministic calculation	Source	Probabilistic analysis[a] Distribution	Parameter 1	Parameter 2	Parameter 3	Parameter 4	Description
Ingestion rates (cont.)										
Livestock intakes (cont.)										
Soil from grain intake for meat cows	kg/d	M	0.4	Code default	None	NR	NR	NR	NR	The daily incidental intake of soil with grain by meat cows kept for meat production.
Water intake for milk cows	L/d	M	160	Code default	None	NR	NR	NR	NR	The daily intake of water by milk cows kept for milk production.
Pasture and silage intake for milk cows	kg/d	M	44	Code default	None	NR	NR	NR	NR	The daily intake of silage or pasture by milk cows kept for milk production.
Grain intake for milk cows	kg/d	M	11	Code default	None	NR	NR	NR	NR	The daily intake of grain by milk cows kept for milk production.
Soil from pasture and silage intake for milk cows	kg/d	M	0.4	Code default	None	NR	NR	NR	NR	The daily incidental intake of soil with silage or pasture by milk cows kept for milk production.
Soil from grain intake for milk cows	kg/d	M	0.1	Code default	None	NR	NR	NR	NR	The daily incidental intake of soil with grain by milk cows kept for milk production.
Livestock feed factors										
Wet weight crop yield of pasture and silage	kg/m^2	P	1.1	Code default	None	NR	NR	NR	NR	The mass (wet weight) of the edible portion of pasture and silage consumed by livestock produced from a unit land area.
Duration of growing season of pasture and silage	yr	P	0.08	Code default	None	NR	NR	NR	NR	The time duration during which the pasture and silage consumed by livestock is exposed to contamination by foliar deposition and root uptake.
Foliage to food transfer coefficient of pasture and silage	—	P	1	Code default	None	NR	NR	NR	NR	The contaminant foliage-to-food transfer coefficient. A fraction of the contaminants that retains on foliage of the pasture and silage that will be absorbed and transferred to the edible portion of the pasture and silage consumed by livestock.

[a] For truncated lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution, parameter 3 = lower quantile, and parameter 4 = upper quantile; for lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution; for triangular distribution, parameter 1 = minimum, parameter 2 = mode or most likely, and parameter 3 = maximum; for truncated normal distribution, parameter 1 = mean, parameter 2 = standard deviation, parameter 3 = lower quantile, and parameter 4 = upper quantile; for bounded lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution, parameter 3 = minimum value, and parameter 4 = maximum value; for uniform distribution, , parameter 1 = minimum, and parameter 2 = maximum; for continuous linear distribution, number of points, value of points, and CDF of points; for continuous logarithmic distribution, number of points, value of points, and CDF of points.

[b] P = physical, B = behavioral, and M = metabolic parameter.

[c] NA = not applicable.

[d] NR = not required.

Table B-42 Base Values and Statistical Distributions of Input Parameters Used in the RESRAD-OFFSITE Code for the Offsite Resident via Water Transport Scenario (cont.)

Input screen title/parameter	Units	Type[b]	Base value for deterministic calculation	Source	Probabilistic analysis[a]					Description
					Distribution	Parameter 1	Parameter 2	Parameter 3	Parameter 4	
Ingestion rates (cont.)										
Livestock feed factors (cont.)										
Weathering removal constant of pasture and silage	1/yr	P	20	Code default	None	NR	NR	NR	NR	The weathering process would remove contaminants from foliage of the pasture and silage consumed by livestock. The process is characterized by a removal constant and it reduces the amount of contaminants on foliage exponentially during the exposure period.
Foliar interception factor for irrigation of pasture and silage	—	P	0.25	Code default	None	NR	NR	NR	NR	The fraction of deposited radionuclides from irrigation that retains on the foliage of the pasture and silage food consumed by livestock.
Foliar interception factor for dust of pasture and silage	—	P	0.25	Code default	None	NR	NR	NR	NR	The fraction of deposited radionuclides from mass loading that retains on the foliage of the pasture and silage food consumed by livestock.
Root depth of pasture and silage	m	P	0.9	Code default	None	NR	NR	NR	NR	The maximum root depth of the pasture and silage consumed by livestock.
Wet weight crop yield of grain	kg/m^2	P	0.7	Code default	None	NR	NR	NR	NR	The mass (wet weight) of the edible portion of grain consumed by livestock produced from a unit land area.
Duration of growing season of grain	yr	P	0.17	Code default	None	NR	NR	NR	NR	The period of time during which the grain consumed by livestock exposed to contamination by foliar deposition and root uptake.
Foliage to food transfer coefficient of grain	—	P	0.1	Code default	None	NR	NR	NR	NR	The contaminant foliage-to-food transfer coefficient. A fraction of the contaminants that retain on foliage of the grain consumed by livestock will be absorbed and transferred to the edible portion of the grain.

[a] For truncated lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution, parameter 3 = lower quantile, and parameter 4 = upper quantile; for lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution; for triangular distribution, parameter 1 = minimum, parameter 2 = mode or most likely, and parameter 3 = maximum; for truncated normal distribution, parameter 1 = mean, parameter 2 = standard deviation, parameter 3 = lower quantile, and parameter 4 = upper quantile; for bounded lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution, parameter 3 = minimum value, and parameter 4 = maximum value; for uniform distribution, , parameter 1 = minimum, and parameter 2 = maximum; for continuous linear distribution, number of points, value of points, and CDF of points; for continuous logarithmic distribution, number of points, value of points, and CDF of points.

[b] P = physical, B = behavioral, and M = metabolic parameter.

[c] NA = not applicable.

[d] NR = not required.

Table B-42 Base Values and Statistical Distributions of Input Parameters Used in the RESRAD-OFFSITE Code for the Offsite Resident via Water Transport Scenario (cont.)

Input screen title/parameter	Units	Type[b]	Base value for deterministic calculation	Source	Probabilistic analysis[a] Distribution	Parameter 1	Parameter 2	Parameter 3	Parameter 4	Description
Ingestion rates (cont.)										
Livestock feed factors (cont.)										
Weathering removal constant of grain	1/yr	P	20	Code default	None	NR	NR	NR	NR	The weathering process would remove contaminants from foliage of the grain consumed by livestock. The process characterized by a removal constant and reduces the amount of contaminants on foliage exponentially during the exposure period.
Foliar interception factor for irrigation of grain	—	P	0.25	Code default	None	NR	NR	NR	NR	The fraction of deposited radionuclides from irrigation that retains on the foliage of the grain consumed by livestock.
Foliar interception factor for dust of grain	—	P	0.25	Code default	None	NR	NR	NR	NR	The fraction of deposited radionuclides from mass loading that retains on the foliage of the grain consumed by livestock.
Root depth of grain	m	P	1.2	Code default	None	NR	NR	NR	NR	The maximum root depth of the grain consumed by livestock.
Plant factors										
Wet weight crop yield of fruit, grain, and non-leafy vegetables	kg/m^2	P	0.7	Code default	None	NR	NR	NR	NR	The mass (wet weight) of the edible portion of fruit, grain, and non-leafy vegetables produced from a unit land area.
Duration of growing season of fruit, grain, and non-leafy vegetables	yr	P	0.17	Code default	None	NR	NR	NR	NR	The period of time during which the fruit, grain, and leafy vegetables exposed to contamination by foliar deposition and root uptake.
Foliage to food transfer coefficient of fruit, grain, and non-leafy vegetables	—	P	0.1	Code default	None	NR	NR	NR	NR	The contaminant foliage-to-food transfer coefficient. A fraction of the contaminants that retain on foliage of the fruit, grain, and non-leafy vegetables will be absorbed and transferred to the edible portion of the pasture and silage.

[a] For truncated lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution, parameter 3 = lower quantile, and parameter 4 = upper quantile; for lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution; for triangular distribution, parameter 1 = minimum, parameter 2 = mode or most likely, and parameter 3 = maximum; for truncated normal distribution, parameter 1 = mean, parameter 2 = standard deviation, parameter 3 = lower quantile, and parameter 4 = upper quantile; for bounded lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution, parameter 3 = minimum value, and parameter 4 = maximum value; for uniform distribution, , parameter 1 = minimum, and parameter 2 = maximum; for continuous linear distribution, number of points, value of points, and CDF of points; for continuous logarithmic distribution, number of points, value of points, and CDF of points.

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[c] NA = not applicable.

[d] NR = not required.

Table B-42 Base Values and Statistical Distributions of Input Parameters Used in the RESRAD-OFFSITE Code for the Offsite Resident via Water Transport Scenario (cont.)

Input screen title/parameter	Units	Type[b]	Base value for deterministic calculation	Source	Probabilistic analysis[a]					Description
					Distribution	Parameter 1	Parameter 2	Parameter 3	Parameter 4	
Ingestion rates (cont.)										
Plant factors (cont.)										
Weathering removal constant of fruit, grain, and non-leafy vegetables	1/yr	P	20	Code default	None	NR	NR	NR	NR	The weathering process would remove contaminants from foliage of the fruit, grain, and non-leafy vegetables. The process characterized by a removal constant and reduces the amount of contaminants on foliage exponentially during the exposure period.
Foliar interception factor for irrigation of fruit, grain, and non-leafy vegetables	—	P	0.25	Code default	None	NR	NR	NR	NR	The fraction of deposited radionuclides from irrigation that is retained on the foliage of the fruit, grain, and non-leafy vegetables.
Foliar interception factor for dust of fruit, grain, and non-leafy vegetables	—	P	0.25	Code default	None	NR	NR	NR	NR	The fraction of deposited radionuclides from mass loading that is retained on the foliage of the fruit, grain, and non-leafy vegetables.
Root depth of fruit, grain, and non-leafy vegetables	m	P	1.2	Code default	None	NR	NR	NR	NR	The maximum root depth of the fruit, grain, and non-leafy vegetables.
Wet weight crop yield of leafy vegetables	kg/m^2	P	1.5	Code default	None	NR	NR	NR	NR	The mass (wet weight) of the edible portion of leafy vegetables produced from a unit land area.
Duration of growing season of leafy vegetables	yr	P	0.25	Code default	None	NR	NR	NR	NR	The period of time during which the leafy vegetables exposed to contamination by foliar deposition and root uptake.
Foliage to food transfer coefficient of leafy vegetables	—	P	1	Code default	None	NR	NR	NR	NR	The contaminant foliage-to-food transfer coefficient. A fraction of the contaminants that retain on foliage of the leafy vegetables will be absorbed and transferred to the edible portion of the pasture and silage.

[a] For truncated lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution, parameter 3 = lower quantile, and parameter 4 = upper quantile; for lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution; for triangular distribution, parameter 1 = minimum, parameter 2 = mode or most likely, and parameter 3 = maximum; for truncated normal distribution, parameter 1 = mean, parameter 2 = standard deviation, parameter 3 = lower quantile, and parameter 4 = upper quantile; for bounded lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution, parameter 3 = minimum value, and parameter 4 = maximum value; for uniform distribution, , parameter 1 = minimum, and parameter 2 = maximum; for continuous linear distribution, number of points, value of points, and CDF of points; for continuous logarithmic distribution, number of points, value of points, and CDF of points.

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Table B-42 Base Values and Statistical Distributions of Input Parameters Used in the RESRAD-OFFSITE Code for the Offsite Resident via Water Transport Scenario (cont.)

Input screen title/parameter	Units	Type[b]	Base value for deterministic calculation	Source	Probabilistic analysis[a]					Description
					Distribution	Parameter 1	Parameter 2	Parameter 3	Parameter 4	
Ingestion rates (cont.)										
Plant factors (cont.)										
Weathering removal constant of leafy vegetables	1/yr	P	20	Code default	None	NR	NR	NR	NR	The weathering process would remove contaminants from foliage of the leafy vegetables. The process characterized by a removal constant and reduces the amount of contaminants on foliage exponentially during the exposure period.
Foliar interception factor for irrigation of leafy vegetables	—	P	0.25	Code default	None	NR	NR	NR	NR	The fraction of deposited radionuclides from irrigation that retains on the foliage of the leafy vegetables.
Foliar interception factor for dust of leafy vegetables	—	P	0.25	Code default	None	NR	NR	NR	NR	The fraction of deposited radionuclides from mass loading that retains on the foliage of the leafy vegetables.
Root depth of leafy vegetables	m	P	0.9	Code default	None	NR	NR	NR	NR	The maximum root depth of the leafy vegetables.
Inhalation and external gamma										
Inhalation rate	m^3/yr	M, B	NA	Inhalation pathway is suppressed in this scenario	NA	NA	NA	NA	NA	The annual air intake
Mass loading of all particulates from primary contamination	g/m^3	P, B	0.0001	For deterministic run, base value selected is the code default. For probabilistic run, distribution from Yu et al. 2007 is used.	Lognormal	-10.02	0.455	0.001	0.999	The mass loading of airborne contaminated soil particles from primary contamination.
Respirable particulates as a fraction of total particulates			NA	Inhalation pathway is suppressed in this scenario	NA	NA	NA	NA	NA	

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[b] P = physical, B = behavioral, and M = metabolic parameter.

[c] NA = not applicable.

[d] NR = not required.

Table B-42 Base Values and Statistical Distributions of Input Parameters Used in the RESRAD-OFFSITE Code for the Offsite Resident via Water Transport Scenario (cont.)

Input screen title/parameter	Units	Type[b]	Base value for deterministic calculation	Source	Probabilistic analysis[a] Distribution	Parameter 1	Parameter 2	Parameter 3	Parameter 4	Description
Inhalation and external gamma (cont.)										
Mass loading and respirable fraction at offsite locations		P, B	Use same value as for primary contamination							The user has an option to input mass loading and respirable fractions at all offsite locations or use the same values as for primary contamination.
Indoor to outdoor dust concentration ratio	—	P, B	NA	Inhalation pathway is suppressed in this scenario	NA	NA	NA	NA	NA	The indoor to outdoor dust concentration ratio describes the effect of the building structure on the level of contaminated dust existing indoors. Specifically, the factor is the fraction of outdoor contaminated dust that will be available indoors.
External gamma penetration factor	—	P	NA	External exposure pathway is suppressed in this scenario	NA	NA	NA	NA	NA	The penetration factor describes the effect of the building structure on the level of gamma radiation existing indoors. Specifically, the penetration factor is the fraction of outdoor gamma radiation that will be available indoors.
External radiation shape and area factors										
Shape of the onsite contamination (shape factor flag)	—	P	Circular	Code default	None	NR	NR	NR	NR	The code has the capability to handle any shape of contaminated area, if the shape factor flag is set. The shape factor data is calculated by drawing 12 concentric circles emanating from the receptor location inside (or possibly outside) the contaminated area. The outermost circle circumscribes the entire contaminated zone. For the innermost circle, the radius is 1/12 of the radius of the outermost circle. For each of the annular rings beyond the innermost circle, the distance between inner and outer radii is 1/12 of the radius of the outermost circle. The code then estimates the fraction of each annular ring within the contaminated zone displayed in the graphic.

[a] For truncated lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution, parameter 3 = lower quantile, and parameter 4 = upper quantile; for lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution; for triangular distribution, parameter 1 = minimum, parameter 2 = mode or most likely, and parameter 3 = maximum; for truncated normal distribution, parameter 1 = mean, parameter 2 = standard deviation, parameter 3 = lower quantile, and parameter 4 = upper quantile; for bounded lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution, parameter 3 = minimum value, and parameter 4 = maximum value; for uniform distribution, , parameter 1 = minimum, and parameter 2 = maximum; for continuous linear distribution, number of points, value of points, and CDF of points; for continuous logarithmic distribution, number of points, value of points, and CDF of points.

[b] P = physical, B = behavioral, and M = metabolic parameter.

[c] NA = not applicable.

[d] NR = not required.

Table B-42 Base Values and Statistical Distributions of Input Parameters Used in the RESRAD-OFFSITE Code for the Offsite Resident via Water Transport Scenario (cont.)

Input screen title/parameter	Units	Type[b]	Base value for deterministic calculation	Source	Probabilistic analysis[a]					Description
					Distribution	Parameter 1	Parameter 2	Parameter 3	Parameter 4	
External radiation shape and area factors (cont.)										
Shape of the offsite contamination (shape factor flag)	—	P	Circular	Parameter not required	NR	NR	NR	NR	NR	Same as above
Occupancy										
Indoor time fraction on primary contamination	—	B	0	Code default	None	NR	NR	NR	NR	The average fraction of time during which an individual stays inside a house built on top of the primary contamination.
Outdoor time fraction on primary contamination	—	B	0	Code default	None	NR	NR	NR	NR	The average fraction of a day during which an individual stays outdoors on the area of primary contamination
Indoor time fraction offsite, at offsite dwelling	—	B	0.5	Code default	None	NR	NR	NR	NR	The average fraction of time during which an individual stays inside a house at offsite dwelling location.
Outdoor time fraction at outside dwelling.	—	B	0.1	Code default	None	NR	NR	NR	NR	The average fraction of a day during which an individual stays outdoors outside at offsite dwelling.
Time fraction in fruit, grain, and non-leafy vegetable fields	—	B	0.1	Code default	None	NR	NR	NR	NR	The average fraction of a day during which an individual stays outside in fruit, grain, and non-leafy vegetable field
Time fraction in leafy vegetable fields	—	B	0.1	Code default	None	NR	NR	NR	NR	The average fraction of a day during which an individual stays outside in leafy vegetable field
Time fraction in pasture and silage fields	—	B	0.1	Code default	None	NR	NR	NR	NR	The average fraction of a day during which an individual stays outside in pasture and silage field
Time fraction in livestock grain fields	—	B	0.1	Code default	None	NR	NR	NR	NR	The average fraction of a day during which an individual stays outside in livestock grain field
Radon										
Effective radon diffusion coefficient of cover	m^2/s	P	NA	Radon inhalation pathway is suppressed in this scenario	NA	NA	NA	NA	NA	The effective (or interstitial) radon diffusion coefficient is the ratio of the gradient of the radon activity concentration in the pore space to the diffusive flux density of radon activity across the pore area. Entering –1 for any diffusion coefficient will cause the code to calculate a diffusion coefficient based on the porosity and water content of the medium.

[a] For truncated lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution, parameter 3 = lower quantile, and parameter 4 = upper quantile; for lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution; for triangular distribution, parameter 1 = minimum, parameter 2 = mode or most likely, and parameter 3 = maximum; for truncated normal distribution, parameter 1 = mean, parameter 2 = standard deviation, parameter 3 = lower quantile, and parameter 4 = upper quantile; for bounded lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution, parameter 3 = minimum value, and parameter 4 = maximum value; for uniform distribution, , parameter 1 = minimum, and parameter 2 = maximum; for continuous linear distribution, number of points, value of points, and CDF of points; for continuous logarithmic distribution, number of points, value of points, and CDF of points.

[b] P = physical, B = behavioral, and M = metabolic parameter.

[c] NA = not applicable.

[d] NR = not required.

Table B-42 Base Values and Statistical Distributions of Input Parameters Used in the RESRAD-OFFSITE Code for the Offsite Resident via Water Transport Scenario (cont.)

Input screen title/parameter	Units	Type[b]	Base value for deterministic calculation	Source	Probabilistic analysis[a]					Description
					Distribution	Parameter 1	Parameter 2	Parameter 3	Parameter 4	
Radon (cont.)										
Effective radon diffusion coefficient of contaminated zone	m^2/s	P	NA	Radon inhalation pathway is suppressed in this scenario	NA	NA	NA	NA	NA	Same as above
Effective radon diffusion coefficient of floor	m^2/s	P	NA	Radon inhalation pathway is suppressed in this scenario	NA	NA	NA	NA	NA	Same as above
Thickness of floor and foundation	m	P	NA	Radon inhalation pathway is suppressed in this scenario	NA	NA	NA	NA	NA	The building foundation thickness is the average thickness of the building shell structure in the subsurface of the soil.
Density of floor and foundation	g/cm^3	P	NA	Radon inhalation pathway is suppressed in this scenario	NA	NA	NA	NA	NA	The building-foundation bulk density is the ratio of the solid-phase mass to the total volume.
Total porosity of floor and foundation	—	P	NA	Radon inhalation pathway is suppressed in this scenario	NA	NA	NA	NA	NA	Total porosity is the ratio of the void-space volume to the total volume of a porous medium.
Volumetric water content of floor and foundation	—	P	NA	Radon inhalation pathway is suppressed in this scenario	NA	NA	NA	NA	NA	The volumetric water content in a porous medium represents the fraction of the total volume of porous medium occupied by the water contained in the porous medium. The value should be less than the total porosity of the porous medium.

[a] For truncated lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution, parameter 3 = lower quantile, and parameter 4 = upper quantile; for lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution; for triangular distribution, parameter 1 = minimum, parameter 2 = mode or most likely, and parameter 3 = maximum; for truncated normal distribution, parameter 1 = mean, parameter 2 = standard deviation, parameter 3 = lower quantile, and parameter 4 = upper quantile; for bounded lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution, parameter 3 = minimum value, and parameter 4 = maximum value; for uniform distribution, , parameter 1 = minimum, and parameter 2 = maximum; for continuous linear distribution, number of points, value of points, and CDF of points; for continuous logarithmic distribution, number of points, value of points, and CDF of points.

[b] P = physical, B = behavioral, and M = metabolic parameter.

[c] NA = not applicable.

[d] NR = not required.

Table B-42 Base Values and Statistical Distributions of Input Parameters Used in the RESRAD-OFFSITE Code for the Offsite Resident via Water Transport Scenario (cont.)

Input screen title/parameter	Units	Type[b]	Base value for deterministic calculation	Source	Probabilistic analysis[a] Distribution	Parameter 1	Parameter 2	Parameter 3	Parameter 4	Description
Radon (cont.)										
Depth of foundation below ground level	m	P	NA	Radon inhalation pathway is suppressed in this scenario	NA	NA	NA	NA	NA	The foundation depth below ground surface is the vertical distance in the soil immediately from the bottom of the basement floor slab to the ground surface. For a negative value, the absolute value will be adjusted (if needed) so the foundation depth will not extend into the contaminated zone. Thus, due to erosion of the cover and contaminated zones, the foundation depth could be time-dependent and less than the (absolute) specified value.
Radon vertical dimension of mixing	m	P	NA	Radon inhalation pathway is suppressed in this scenario	NA	NA	NA	NA	NA	Radon vertical dimension of mixing is the height into which the plume of radon is uniformly mixed in the outdoor air.
Building room height	m	P	NA	Radon inhalation pathway is suppressed in this scenario	NA	NA	NA	NA	NA	The building room height is the average height of the rooms in the building.
Building air exchange rate	1/hr	B	NA	Radon inhalation pathway is suppressed in this scenario	NA	NA	NA	NA	NA	The building air exchange (or ventilation) rate is the number of the total volumes of air contained in the building exchanged with outside air per unit of time.

[a] For truncated lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution, parameter 3 = lower quantile, and parameter 4 = upper quantile; for lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution; for triangular distribution, parameter 1 = minimum, parameter 2 = mode or most likely, and parameter 3 = maximum; for truncated normal distribution, parameter 1 = mean, parameter 2 = standard deviation, parameter 3 = lower quantile, and parameter 4 = upper quantile; for bounded lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution, parameter 3 = minimum value, and parameter 4 = maximum value; for uniform distribution, , parameter 1 = minimum, and parameter 2 = maximum; for continuous linear distribution, number of points, value of points, and CDF of points; for continuous logarithmic distribution, number of points, value of points, and CDF of points.

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[c] NA = not applicable.

[d] NR = not required.

Table B-42 Base Values and Statistical Distributions of Input Parameters Used in the RESRAD-OFFSITE Code for the Offsite Resident via Water Transport Scenario (cont.)

Input screen title/parameter	Units	Type[b]	Base value for deterministic calculation	Source	Probabilistic analysis[a]					Description
					Distribution	Parameter 1	Parameter 2	Parameter 3	Parameter 4	
Radon (cont.)										
Building indoor area factor	—	P	NA	Radon inhalation pathway is suppressed in this scenario	NA	NA	NA	NA	NA	The building indoor area factor is the fraction of the floor area built on the contaminated area. Values greater than 1.0 indicate a contribution from walls extending into the contaminated zone. A default value of 0.0 means the code will calculate automatically a time-dependent area factor for floor area of 100 m^2 and the amount of wall area extending into the contaminated zone.
Rn-222 emanation coefficient	—	P	NA	Radon inhalation pathway is suppressed in this scenario	NA	NA	NA	NA	NA	The radon emanation coefficient for Rn-222 is the fraction of the total Rn-222 generated by radium decay that escapes from the soil particles. The emanating power is dependent upon on many factors, such as mineralogy, porosity, particle size distribution, and moisture content.
Rn-220 emanation coefficient	—	P	NA	Radon inhalation pathway is suppressed in this scenario	NA	NA	NA	NA	NA	The radon emanation coefficient for Rn-220 is the fraction of the total Rn-220 generated by radium decay that escapes from the soil particles. The emanating power is dependent upon on many factors, such as mineralogy, porosity, particle size distribution, and moisture content.
Effective radon diffusion coefficient of non-leafy vegetable field	m^2/s	P	NA	Radon inhalation pathway is suppressed in this scenario	NA	NA	NA	NA	NA	See cover effective radon diffusion coefficient
Effective radon diffusion coefficient of leafy vegetable field	m^2/s	P	NA	Radon inhalation pathway is suppressed in this scenario	NA	NA	NA	NA	NA	See cover Effective radon diffusion coefficient

[a] For truncated lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution, parameter 3 = lower quantile, and parameter 4 = upper quantile; for lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution; for triangular distribution, parameter 1 = minimum, parameter 2 = mode or most likely, and parameter 3 = maximum; for truncated normal distribution, parameter 1 = mean, parameter 2 = standard deviation, parameter 3 = lower quantile, and parameter 4 = upper quantile; for bounded lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution, parameter 3 = minimum value, and parameter 4 = maximum value; for uniform distribution, , parameter 1 = minimum, and parameter 2 = maximum; for continuous linear distribution, number of points, value of points, and CDF of points; for continuous logarithmic distribution, number of points, value of points, and CDF of points.

[b] P = physical, B = behavioral, and M = metabolic parameter.

[c] NA = not applicable.

[d] NR = not required.

Table B-42 Base Values and Statistical Distributions of Input Parameters Used in the RESRAD-OFFSITE Code for the Offsite Resident via Water Transport Scenario (cont.)

Input screen title/parameter	Units	Type[b]	Base value for deterministic calculation	Source	Probabilistic analysis[a] Distribution	Parameter 1	Parameter 2	Parameter 3	Parameter 4	Description
Radon (cont.)										
Effective radon diffusion coefficient of pasture and silage field	m^2/s	P	NA	Radon inhalation pathway is suppressed in this scenario	NA	NA	NA	NA	NA	See cover effective radon diffusion coefficient
Effective radon diffusion coefficient of livestock grain field	m^2/s	P	NA	Radon inhalation pathway is suppressed in this scenario	NA	NA	NA	NA	NA	See cover effective radon diffusion coefficient”
Effective radon diffusion coefficient of offsite dwelling site	m^2/s	P	NA	Radon inhalation pathway is suppressed in this scenario	NA	NA	NA	NA	NA	See cover effective radon diffusion coefficient
Carbon-14										
Thickness of evasion layer for C-14 in soil	m	P	0.3	For deterministic run, the default value selected is the default used in the code. For probabilistic run, distribution from NUREG/CR-6697 is used.	Triangular	2.00E-01	3.00E-01	6.00E-01	NR	The maximum soil thickness layer through which C-14 can escape to the air by conversion to CO_2. C-14 below this depth cannot escape.
Vertical dimension of mixing for inhalation	m	P	NA	Inhalation pathway is suppressed in this scenario	NA	NA	NA	NA	NA	This vertical dimension together with the area of primary contamination is used to compute the onsite concentration of C-14 for inhalation.

[a] For truncated lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution, parameter 3 = lower quantile, and parameter 4 = upper quantile; for lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution; for triangular distribution, parameter 1 = minimum, parameter 2 = mode or most likely, and parameter 3 = maximum; for truncated normal distribution, parameter 1 = mean, parameter 2 = standard deviation, parameter 3 = lower quantile, and parameter 4 = upper quantile; for bounded lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution, parameter 3 = minimum value, and parameter 4 = maximum value; for uniform distribution, , parameter 1 = minimum, and parameter 2 = maximum; for continuous linear distribution, number of points, value of points, and CDF of points; for continuous logarithmic distribution, number of points, value of points, and CDF of points.

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[c] NA = not applicable.

[d] NR = not required.

Table B-42 Base Values and Statistical Distributions of Input Parameters Used in the RESRAD-OFFSITE Code for the Offsite Resident via Water Transport Scenario (cont.)

Input screen title/parameter	Units	Type[b]	Base value for deterministic calculation	Source	Probabilistic analysis[a]					Description
					Distribution	Parameter 1	Parameter 2	Parameter 3	Parameter 4	
Carbon-14 (cont.)										
Vertical dimension of mixing for vegetation	m	P	1	For deterministic run, base value selected is the code default. For probabilistic run, uniform distribution from 1/2 to twice the base value	Uniform	0.5	2			This vertical dimension together with the area of primary contamination is used to compute the onsite concentration of C-14 for vegetation.
C-14 evasion flux rate from soil	1/s	P	0.0000007	The value used is from the default used in the code. The parameter has triangular distribution with the default as the mode in the distribution and the minimum value of the distribution is 1/2 of the default value, and the maximum value of the distribution is two times the default value.	Triangular	3.50E-07	7.00E-07	1.40E-06		The fraction of the soil inventory of C-14 lost to the atmosphere per unit time.

a For truncated lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution, parameter 3 = lower quantile, and parameter 4 = upper quantile; for lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution; for triangular distribution, parameter 1 = minimum, parameter 2 = mode or most likely, and parameter 3 = maximum; for truncated normal distribution, parameter 1 = mean, parameter 2 = standard deviation, parameter 3 = lower quantile, and parameter 4 = upper quantile; for bounded lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution, parameter 3 = minimum value, and parameter 4 = maximum value; for uniform distribution, , parameter 1 = minimum, and parameter 2 = maximum; for continuous linear distribution, number of points, value of points, and CDF of points; for continuous logarithmic distribution, number of points, value of points, and CDF of points.

b P = physical, B = behavioral, and M = metabolic parameter.

c NA = not applicable.

d NR = not required.

Table B-42 Base Values and Statistical Distributions of Input Parameters Used in the RESRAD-OFFSITE Code for the Offsite Resident via Water Transport Scenario (cont.)

Input screen title/parameter	Units	Type[b]	Base value for deterministic calculation	Source	Probabilistic analysis[a]					Description
					Distribution	Parameter 1	Parameter 2	Parameter 3	Parameter 4	
Carbon-14 (cont.)										
C-12 evasion flux rate from soil	1/s	P	1E-10	The value used is from the default used in the code. The parameter has triangular distribution with the default as the mode in the distribution and the minimum value of the distribution is 1/2 of the default value, and the maximum value of the distribution is two times the default value.	Triangular	5.00E-11	1.00E-10	2.00E-10		The fraction of C-12 in soil that escapes to the atmosphere per unit time.

[a] For truncated lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution, parameter 3 = lower quantile, and parameter 4 = upper quantile; for lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution; for triangular distribution, parameter 1 = minimum, parameter 2 = mode or most likely, and parameter 3 = maximum; for truncated normal distribution, parameter 1 = mean, parameter 2 = standard deviation, parameter 3 = lower quantile, and parameter 4 = upper quantile; for bounded lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution, parameter 3 = minimum value, and parameter 4 = maximum value; for uniform distribution, , parameter 1 = minimum, and parameter 2 = maximum; for continuous linear distribution, number of points, value of points, and CDF of points; for continuous logarithmic distribution, number of points, value of points, and CDF of points.

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[c] NA = not applicable.

[d] NR = not required.

Table B-42 Base Values and Statistical Distributions of Input Parameters Used in the RESRAD-OFFSITE Code for the Offsite Resident via Water Transport Scenario (cont.)

Input screen title/parameter	Units	Type[b]	Base value for deterministic calculation	Source	Probabilistic analysis[a]					Description
					Distribution	Parameter 1	Parameter 2	Parameter 3	Parameter 4	
Carbon-14 (cont.)										
Fraction of vegetation carbon absorbed from soil	—	P	0.02	The value used is from the default used in the code for fraction of vegetation carbon absorbed from soil. The parameter has triangular distribution with the default as the mode in the distribution and the minimum value of the distribution is 1/2 of the default value, and the maximum value of the distribution is two times the default value.	Triangular	1.00E-02	2.00E-02	4.00E-02		The fraction of total vegetation carbon obtained by direct root uptake from the soil.

[a] For truncated lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution, parameter 3 = lower quantile, and parameter 4 = upper quantile; for lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution; for triangular distribution, parameter 1 = minimum, parameter 2 = mode or most likely, and parameter 3 = maximum; for truncated normal distribution, parameter 1 = mean, parameter 2 = standard deviation, parameter 3 = lower quantile, and parameter 4 = upper quantile; for bounded lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution, parameter 3 = minimum value, and parameter 4 = maximum value; for uniform distribution, , parameter 1 = minimum, and parameter 2 = maximum; for continuous linear distribution, number of points, value of points, and CDF of points; for continuous logarithmic distribution, number of points, value of points, and CDF of points.

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[c] NA = not applicable.

[d] NR = not required.

Table B-42 Base Values and Statistical Distributions of Input Parameters Used in the RESRAD-OFFSITE Code for the Offsite Resident via Water Transport Scenario (cont.)

Input screen title/parameter	Units	Type[b]	Base value for deterministic calculation	Source	Probabilistic analysis[a] Distribution	Parameter 1	Parameter 2	Parameter 3	Parameter 4	Description
Carbon-14 (cont.)										
Fraction of vegetation carbon absorbed from air	—	P	0.98	The value used is from the default used in the code for fraction of vegetation carbon absorbed from soil. The parameter has triangular distribution with the default as the mode in the distribution and the minimum and maximum value of the distribution were determined by using the maximum and minimum, respectively, of the previous parameter.	Triangular	9.60E-01	9.80E-01	9.90E-01		The fraction of total vegetation carbon assimilated from the atmosphere through photosynthesis.

[a] For truncated lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution, parameter 3 = lower quantile, and parameter 4 = upper quantile; for lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution; for triangular distribution, parameter 1 = minimum, parameter 2 = mode or most likely, and parameter 3 = maximum; for truncated normal distribution, parameter 1 = mean, parameter 2 = standard deviation, parameter 3 = lower quantile, and parameter 4 = upper quantile; for bounded lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution, parameter 3 = minimum value, and parameter 4 = maximum value; for uniform distribution, , parameter 1 = minimum, and parameter 2 = maximum; for continuous linear distribution, number of points, value of points, and CDF of points; for continuous logarithmic distribution, number of points, value of points, and CDF of points.

[b] P = physical, B = behavioral, and M = metabolic parameter.

[c] NA = not applicable.

[d] NR = not required.

Table B-42 Base Values and Statistical Distributions of Input Parameters Used in the RESRAD-OFFSITE Code for the Offsite Resident via Water Transport Scenario (cont.)

Input screen title/parameter	Units	Type[b]	Base value for deterministic calculation	Source	Probabilistic analysis[a]					Description
					Distribution	Parameter 1	Parameter 2	Parameter 3	Parameter 4	
Mass fractions and concentrations of Carbon-12										
C-12 concentration in atmosphere	g/m^3	P	0.18	For deterministic run, base value selected is the code default. For probabilistic run, uniform distribution from +/- 10 percent to the base value	Uniform	0.162	0.198			This parameter is the C-12 concentration in the atmosphere
C-12 concentration in contaminated soil	g/g	P	0.03	The value used is the code default. The parameter has triangular distribution with the default as the mode in the distribution and the minimum value of the distribution is 1/2 of the default value, and the maximum value of the distribution is two times the default value.	Triangular	1.50E-02	3.00E-02	6.00E-02		This parameter is the C-12 concentration in the contaminated zone in g/g.

[a] For truncated lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution, parameter 3 = lower quantile, and parameter 4 = upper quantile; for lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution; for triangular distribution, parameter 1 = minimum, parameter 2 = mode or most likely, and parameter 3 = maximum; for truncated normal distribution, parameter 1 = mean, parameter 2 = standard deviation, parameter 3 = lower quantile, and parameter 4 = upper quantile; for bounded lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution, parameter 3 = minimum value, and parameter 4 = maximum value; for uniform distribution, , parameter 1 = minimum, and parameter 2 = maximum; for continuous linear distribution, number of points, value of points, and CDF of points; for continuous logarithmic distribution, number of points, value of points, and CDF of points.

[b] P = physical, B = behavioral, and M = metabolic parameter.

[c] NA = not applicable.

[d] NR = not required.

Table B-42 Base Values and Statistical Distributions of Input Parameters Used in the RESRAD-OFFSITE Code for the Offsite Resident via Water Transport Scenario (cont.)

Input screen title/parameter	Units	Type[b]	Base value for deterministic calculation	Source	Probabilistic analysis[a] Distribution	Parameter 1	Parameter 2	Parameter 3	Parameter 4	Description
Mass fractions and concentrations of Carbon-12 (cont.)										
C-12 concentration in local water	g/cm^3	P	2E-5	The value used is from the default used in the code for fraction of carbon in water. The parameter has triangular distribution with the default as the mode in the distribution and the minimum value of the distribution is 1/10 of the default value, and the maximum value of the distribution is ten times the default value.	Triangular	2.00E-06	2.00E-05	2.00E-04		This parameter is the C-12 concentration in the local water.
C-12 concentration in fruit, grain, non-leafy vegetables	—	P	0.4	For deterministic run, base value selected is the code default. For probabilistic run, uniform distribution from +/- 10 percent to the base value.	Uniform	0.36	0.44			The mass of C-12 in a unit mass of fruit, grain, and non-leafy vegetables.

[a] For truncated lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution, parameter 3 = lower quantile, and parameter 4 = upper quantile; for lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution; for triangular distribution, parameter 1 = minimum, parameter 2 = mode or most likely, and parameter 3 = maximum; for truncated normal distribution, parameter 1 = mean, parameter 2 = standard deviation, parameter 3 = lower quantile, and parameter 4 = upper quantile; for bounded lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution, parameter 3 = minimum value, and parameter 4 = maximum value; for uniform distribution, , parameter 1 = minimum, and parameter 2 = maximum; for continuous linear distribution, number of points, value of points, and CDF of points; for continuous logarithmic distribution, number of points, value of points, and CDF of points.

[b] P = physical, B = behavioral, and M = metabolic parameter.

[c] NA = not applicable.

[d] NR = not required.

Table B-42 Base Values and Statistical Distributions of Input Parameters Used in the RESRAD-OFFSITE Code for the Offsite Resident via Water Transport Scenario (cont.)

Input screen title/parameter	Units	Type[b]	Base value for deterministic calculation	Source	Probabilistic analysis[a] Distribution	Parameter 1	Parameter 2	Parameter 3	Parameter 4	Description
Mass fractions and concentrations of Carbon-12 (cont.)										
C-12 concentration in leafy vegetables	—	P	0.09	For deterministic run, base value selected is the code default. For probabilistic run, uniform distribution from +/- 10 percent to the base value.	Uniform	0.081	0.099			The mass of C-12 in a unit mass of leafy vegetables.
C-12 concentration in pasture and silage	—	P	0.09	For deterministic run, base value selected is the code default. For probabilistic run, uniform distribution from +/- 10 percent to the base value.	Uniform	0.081	0.099			The mass of C-12 in a unit mass of pasture and silage.
C-12 concentration in grain	—	P	0.4	For deterministic run, base value selected is the code default. For probabilistic run, uniform distribution from +/- 10 percent to the base value.	Uniform	0.36	0.44			The mass of C-12 in a unit mass of grain.
Tritium										
Humidity in air	g/m^3	P	NR	Not required	NR	NR	NR	NR	NR	Air humidity is for the computation of tritium concentration in air.

[a] For truncated lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution, parameter 3 = lower quantile, and parameter 4 = upper quantile; for lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution; for triangular distribution, parameter 1 = minimum, parameter 2 = mode or most likely, and parameter 3 = maximum; for truncated normal distribution, parameter 1 = mean, parameter 2 = standard deviation, parameter 3 = lower quantile, and parameter 4 = upper quantile; for bounded lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution, parameter 3 = minimum value, and parameter 4 = maximum value; for uniform distribution, , parameter 1 = minimum, and parameter 2 = maximum; for continuous linear distribution, number of points, value of points, and CDF of points; for continuous logarithmic distribution, number of points, value of points, and CDF of points.

[b] P = physical, B = behavioral, and M = metabolic parameter.

[c] NA = not applicable.

[d] NR = not required.

Table B-42 Base Values and Statistical Distributions of Input Parameters Used in the RESRAD-OFFSITE Code for the Offsite Resident via Water Transport Scenario (cont.)

Input screen title/parameter	Units	Type[b]	Base value for deterministic calculation	Source	Probabilistic analysis[a]					Description
					Distribution	Parameter 1	Parameter 2	Parameter 3	Parameter 4	
Tritium (cont.)										
Water fraction in fruit, grain, and non-leafy vegetables	—	P	0.8	For deterministic run, base value selected is the code default. For probabilistic run, uniform distribution from +/- 10 percent to the base value.	Uniform	0.72	0.88			The mass of water in a unit mass of fruit, grain, and non-leafy vegetables.
Water fraction in leafy vegetable	—	P	0.8	For deterministic run, base value selected is the code default. For probabilistic run, uniform distribution from +/- 10 percent to the base value.	Uniform	0.72	0.88			The mass of water in a unit mass of leafy vegetables.
Water fraction in pasture and silage	—	P	0.8	For deterministic run, base value selected is the code default. For probabilistic run, uniform distribution from +/- 10 percent to the base value.	Uniform	0.72	0.88			The mass of water in a unit mass of pasture and silage.

[a] For truncated lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution, parameter 3 = lower quantile, and parameter 4 = upper quantile; for lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution; for triangular distribution, parameter 1 = minimum, parameter 2 = mode or most likely, and parameter 3 = maximum; for truncated normal distribution, parameter 1 = mean, parameter 2 = standard deviation, parameter 3 = lower quantile, and parameter 4 = upper quantile; for bounded lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution, parameter 3 = minimum value, and parameter 4 = maximum value; for uniform distribution, , parameter 1 = minimum, and parameter 2 = maximum; for continuous linear distribution, number of points, value of points, and CDF of points; for continuous logarithmic distribution, number of points, value of points, and CDF of points.

[b] P = physical, B = behavioral, and M = metabolic parameter.

[c] NA = not applicable.

[d] NR = not required.

Table B-42 Base Values and Statistical Distributions of Input Parameters Used in the RESRAD-OFFSITE Code for the Offsite Resident via Water Transport Scenario (cont.)

Input screen title/parameter	Units	Type[b]	Base value for deterministic calculation	Source	Probabilistic analysis[a]					Description
					Distribution	Parameter 1	Parameter 2	Parameter 3	Parameter 4	
Tritium (cont.)										
Water fraction in grain	—	P	0.8	For deterministic run, base value selected is the code default. For probabilistic run, uniform distribution from +/- 10 percent to the base value.	Uniform	0.72	0.88			The mass of water in a unit mass of grain.
Water fraction in meat	—	P	0.6	For deterministic run, base value selected is the code default. For probabilistic run, uniform distribution from +/- 10 percent to the base value.	Uniform	0.54	0.66			The mass of water in a unit mass of meat.
Water fraction in milk	—	P	0.88	For deterministic run, base value selected is the code default. For probabilistic run, uniform distribution from +/- 10 percent to the base value.	Uniform	0.792	0.968			The mass of water in a unit mass of milk.

[a] For truncated lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution, parameter 3 = lower quantile, and parameter 4 = upper quantile; for lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution; for triangular distribution, parameter 1 = minimum, parameter 2 = mode or most likely, and parameter 3 = maximum; for truncated normal distribution, parameter 1 = mean, parameter 2 = standard deviation, parameter 3 = lower quantile, and parameter 4 = upper quantile; for bounded lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution, parameter 3 = minimum value, and parameter 4 = maximum value; for uniform distribution, , parameter 1 = minimum, and parameter 2 = maximum; for continuous linear distribution, number of points, value of points, and CDF of points; for continuous logarithmic distribution, number of points, value of points, and CDF of points.

[b] P = physical, B = behavioral, and M = metabolic parameter.

[c] NA = not applicable.

[d] NR = not required.

Table B-42 Base Values and Statistical Distributions of Input Parameters Used in the RESRAD-OFFSITE Code for the Offsite Resident via Water Transport Scenario (cont.)

Input screen title/parameter	Units	Type[b]	Base value for deterministic calculation	Source	Probabilistic analysis[a]					Description
					Distribution	Parameter 1	Parameter 2	Parameter 3	Parameter 4	
Tritium (cont.)										
Vertical dimension of mixing for inhalation	m	P	NA	Inhalation pathway is suppressed in this scenario	NA	NA	NA	NA	NA	This vertical dimension together with the area of primary contamination is to define the mixing volume used to compute the onsite concentration of H-3 for inhalation.

[a] For truncated lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution, parameter 3 = lower quantile, and parameter 4 = upper quantile; for lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution; for triangular distribution, parameter 1 = minimum, parameter 2 = mode or most likely, and parameter 3 = maximum; for truncated normal distribution, parameter 1 = mean, parameter 2 = standard deviation, parameter 3 = lower quantile, and parameter 4 = upper quantile; for bounded lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution, parameter 3 = minimum value, and parameter 4 = maximum value; for uniform distribution, , parameter 1 = minimum, and parameter 2 = maximum; for continuous linear distribution, number of points, value of points, and CDF of points; for continuous logarithmic distribution, number of points, value of points, and CDF of points.

[b] P = physical, B = behavioral, and M = metabolic parameter.

[c] NA = not applicable.

[d] NR = not required.

Table B-43 Distributions of Peak Total Dose and Peak Pathway Dose Obtained with Probabilistic Calculations for Offsite Resident via Water Transport Scenario Concerning C-14 Contamination (mrem/yr per pCi/g)

Percentile	All pathways	Water release						CZ and air[a]			
		Fish ingestion	Plant ingestion	Meat ingestion	Milk ingestion	Soil ingestion	Water ingestion	Plant ingestion	Meat ingestion	Milk ingestion	Soil ingestion
5	2.74E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.80E-04	4.21E-05	1.47E-05	0.00E+00
10	3.55E-04	0.00E+00	7.65E-23	1.81E-23	8.84E-24	1.53E-27	1.22E-23	2.34E-04	5.47E-05	1.90E-05	0.00E+00
15	4.25E-04	7.16E-11	2.46E-09	1.22E-09	6.04E-10	5.62E-14	4.34E-10	2.72E-04	6.36E-05	2.21E-05	0.00E+00
20	4.78E-04	9.97E-07	1.31E-08	5.99E-09	2.98E-09	2.53E-13	2.66E-09	3.05E-04	7.12E-05	2.47E-05	3.39E-22
25	5.38E-04	5.21E-06	2.93E-08	1.42E-08	7.04E-09	6.18E-13	6.50E-09	3.32E-04	7.79E-05	2.72E-05	8.39E-17
30	5.97E-04	1.43E-05	6.01E-08	2.81E-08	1.39E-08	1.18E-12	1.23E-08	3.62E-04	8.44E-05	2.94E-05	5.64E-16
35	6.60E-04	2.87E-05	1.06E-07	4.75E-08	2.37E-08	2.05E-12	2.05E-08	3.90E-04	9.08E-05	3.15E-05	2.23E-15
40	7.25E-04	5.31E-05	1.68E-07	8.13E-08	3.83E-08	3.33E-12	3.36E-08	4.16E-04	9.70E-05	3.36E-05	6.58E-15
45	7.95E-04	8.70E-05	2.55E-07	1.22E-07	5.83E-08	5.10E-12	5.04E-08	4.42E-04	1.03E-04	3.58E-05	1.71E-14
50	8.77E-04	1.47E-04	3.86E-07	1.81E-07	8.79E-08	7.44E-12	7.32E-08	4.69E-04	1.09E-04	3.81E-05	4.55E-14
55	9.87E-04	2.29E-04	5.63E-07	2.70E-07	1.29E-07	1.10E-11	1.02E-07	5.00E-04	1.16E-04	4.06E-05	1.04E-13
60	1.11E-03	3.46E-04	8.50E-07	3.89E-07	1.87E-07	1.56E-11	1.45E-07	5.30E-04	1.23E-04	4.30E-05	2.71E-13
65	1.29E-03	5.09E-04	1.23E-06	5.62E-07	2.74E-07	2.35E-11	2.10E-07	5.64E-04	1.31E-04	4.58E-05	6.49E-13
70	1.55E-03	7.61E-04	1.80E-06	8.30E-07	3.98E-07	3.50E-11	2.89E-07	5.99E-04	1.40E-04	4.87E-05	1.64E-12
75	1.96E-03	1.20E-03	2.65E-06	1.23E-06	5.90E-07	5.09E-11	4.12E-07	6.40E-04	1.50E-04	5.20E-05	3.91E-12
80	2.72E-03	1.94E-03	4.12E-06	2.00E-06	9.31E-07	8.10E-11	6.03E-07	6.90E-04	1.62E-04	5.59E-05	1.17E-11
85	4.13E-03	3.26E-03	7.29E-06	3.40E-06	1.57E-06	1.40E-10	9.15E-07	7.44E-04	1.76E-04	6.05E-05	3.71E-11
90	6.86E-03	6.07E-03	1.43E-05	7.06E-06	3.22E-06	2.63E-10	1.58E-06	8.19E-04	1.92E-04	6.63E-05	1.56E-10
95	1.56E-02	1.46E-02	3.83E-05	1.76E-05	7.87E-06	6.50E-10	3.71E-06	9.28E-04	2.21E-04	7.58E-05	7.70E-10
max	2.69E+00	2.68E+00	8.51E-03	2.29E-03	8.28E-04	6.00E-08	1.12E-04	1.61E-03	3.94E-04	1.43E-04	7.29E-08
mean	5.77E-03	5.12E-03	1.56E-05	6.41E-06	2.87E-06	2.15E-10	8.16E-07	5.02E-04	1.18E-04	4.08E-05	2.63E-10
95/50	1.78E+01	9.93E+01	9.92E+01	9.72E+01	8.95E+01	8.74E+01	5.07E+01	1.98E+00	2.03E+00	1.99E+00	1.69E+04
95 - 50	1.47E-02	1.45E-02	3.79E-05	1.74E-05	7.78E-06	6.43E-10	3.64E-06	4.59E-04	1.12E-04	3.77E-05	7.70E-10

[a] Dose directly from primary contamination and air transport.

Note: Any pathway with 50th or 95th percentile dose that is more than 5 percent of the 50th or 95th percentile dose from all pathways, respectively was considered significant in this analysis and is highlighted. Different colors are used in different rows.

Table B-44 Distributions of Peak Total Dose and Peak Pathway Dose Obtained with Probabilistic Calculations for Offsite Resident via Water Transport Scenario Concerning Co-60 Contamination (mrem/yr per pCi/g)

Percentile	All pathways	Water release						CZ and air[a]			
		Fish ingestion	Plant ingestion	Meat ingestion	Milk ingestion	Soil ingestion	Water ingestion	Plant ingestion	Meat ingestion	Milk ingestion	Soil ingestion
5	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
10	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
15	2.22E-20	9.50E-21	1.64E-21	8.12E-23	8.14E-23	9.96E-25	3.72E-21	9.64E-27	1.78E-30	1.30E-31	6.67E-26
20	4.75E-13	2.28E-13	4.12E-14	2.57E-15	1.87E-15	1.87E-17	9.91E-14	2.76E-20	3.02E-23	3.84E-24	1.04E-19
25	5.54E-12	2.73E-12	4.21E-13	2.58E-14	2.14E-14	1.82E-16	9.69E-13	2.11E-17	1.45E-19	3.05E-20	2.36E-18
30	2.06E-11	9.14E-12	1.47E-12	9.89E-14	8.10E-14	6.73E-16	3.47E-12	4.72E-16	5.79E-18	1.38E-18	1.42E-17
35	5.54E-11	2.46E-11	3.89E-12	2.64E-13	2.21E-13	1.72E-15	8.92E-12	3.72E-15	6.88E-17	1.68E-17	5.46E-17
40	1.29E-10	6.14E-11	9.53E-12	6.24E-13	5.17E-13	4.17E-15	2.19E-11	1.63E-14	2.96E-16	7.96E-17	2.00E-16
45	2.94E-10	1.43E-10	2.23E-11	1.50E-12	1.18E-12	1.04E-14	5.24E-11	6.34E-14	1.21E-15	3.03E-16	6.74E-16
50	7.37E-10	3.13E-10	5.22E-11	3.50E-12	2.79E-12	2.39E-14	1.18E-10	2.36E-13	4.05E-15	1.26E-15	2.14E-15
55	1.68E-09	7.39E-10	1.19E-10	8.15E-12	6.75E-12	5.64E-14	2.86E-10	7.75E-13	1.43E-14	4.13E-15	5.54E-15
60	3.50E-09	1.66E-09	2.68E-10	1.75E-11	1.56E-11	1.25E-13	6.51E-10	2.28E-12	4.51E-14	1.37E-14	1.62E-14
65	8.62E-09	3.96E-09	5.88E-10	3.79E-11	3.62E-11	2.66E-13	1.44E-09	7.22E-12	1.67E-13	4.18E-14	4.66E-14
70	1.95E-08	8.90E-09	1.44E-09	9.43E-11	8.28E-11	6.79E-13	3.47E-09	2.42E-11	4.83E-13	1.38E-13	1.41E-13
75	4.53E-08	2.09E-08	3.18E-09	2.14E-10	1.75E-10	1.51E-12	7.55E-09	7.27E-11	1.57E-12	4.91E-13	3.91E-13
80	1.05E-07	4.80E-08	7.61E-09	5.17E-10	4.12E-10	3.33E-12	1.80E-08	2.43E-10	5.44E-12	1.67E-12	1.19E-12
85	2.51E-07	1.22E-07	2.03E-08	1.38E-09	1.06E-09	8.97E-12	4.50E-08	1.08E-09	2.34E-11	6.84E-12	5.25E-12
90	7.09E-07	3.46E-07	5.22E-08	4.33E-09	3.28E-09	2.47E-11	1.24E-07	5.87E-09	1.37E-10	3.58E-11	2.61E-11
95	3.36E-06	1.72E-06	2.74E-07	1.89E-08	1.61E-08	1.27E-10	6.36E-07	5.76E-08	1.28E-09	3.62E-10	2.53E-10
max	2.57E-04	1.51E-04	7.32E-05	1.66E-05	2.27E-06	6.93E-08	6.93E-05	4.90E-05	1.84E-06	7.64E-07	4.13E-07
mean	1.16E-06	6.70E-07	1.23E-07	1.18E-08	7.71E-09	6.51E-11	2.52E-07	1.04E-07	2.95E-09	6.95E-10	4.98E-10
95/50	4.56E+03	5.50E+03	5.25E+03	5.40E+03	5.77E+03	5.31E+03	5.39E+03	2.44E+05	3.16E+05	2.87E+05	1.18E+05
95 - 50	3.36E-06	1.72E-06	2.74E-07	1.89E-08	1.61E-08	1.27E-10	6.36E-07	5.76E-08	1.28E-09	3.62E-10	2.53E-10

[a] Dose directly from primary contamination and air transport.

Note: Any pathway with 50th or 95th percentile dose that is more than 5 percent of the 50th or 95th percentile dose from all pathways, respectively was considered significant in this analysis and is highlighted. Different colors are used in different rows.

Table B-45 Distributions of Peak Total Dose and Peak Pathway Dose Obtained with Probabilistic Calculations for Offsite Resident via Water Transport Scenario Concerning Cs-137 Contamination (mrem/yr per pCi/g)

Percentile	All pathways	Water release						CZ and air[a]			
		Fish Ingestion	Plant ingestion	Meat ingestion	Milk ingestion	Soil ingestion	Water ingestion	Plant ingestion	Meat ingestion	Milk ingestion	Soil ingestion
5	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
10	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
15	7.67E-09	4.70E-09	1.16E-10	2.59E-10	2.07E-10	2.10E-13	2.26E-10	1.42E-20	1.06E-23	9.03E-25	8.18E-16
20	1.40E-07	7.81E-08	1.77E-09	3.92E-09	3.60E-09	4.03E-12	3.86E-09	1.63E-14	6.06E-16	6.25E-17	1.81E-14
25	4.68E-07	2.73E-07	5.77E-09	1.36E-08	1.11E-08	1.24E-11	1.23E-08	7.57E-13	2.07E-13	4.56E-14	9.45E-14
30	1.03E-06	6.17E-07	1.29E-08	3.12E-08	2.46E-08	2.60E-11	2.72E-08	5.25E-12	1.86E-12	4.50E-13	3.47E-13
35	2.02E-06	1.14E-06	2.39E-08	6.09E-08	4.40E-08	4.79E-11	4.96E-08	2.34E-11	8.58E-12	2.25E-12	1.09E-12
40	3.37E-06	2.02E-06	4.01E-08	1.04E-07	7.34E-08	8.13E-11	8.69E-08	7.31E-11	2.92E-11	8.62E-12	2.61E-12
45	5.45E-06	3.40E-06	6.18E-08	1.69E-07	1.24E-07	1.37E-10	1.32E-07	1.96E-10	9.22E-11	2.48E-11	6.25E-12
50	8.30E-06	5.35E-06	9.57E-08	2.70E-07	1.93E-07	2.15E-10	2.06E-07	5.55E-10	2.47E-10	7.08E-11	1.51E-11
55	1.26E-05	8.18E-06	1.46E-07	4.35E-07	2.99E-07	3.14E-10	3.18E-07	1.45E-09	6.32E-10	1.64E-10	3.49E-11
60	1.87E-05	1.23E-05	2.22E-07	6.32E-07	4.57E-07	4.74E-10	4.69E-07	3.47E-09	1.59E-09	4.21E-10	7.33E-11
65	2.89E-05	1.84E-05	3.25E-07	9.49E-07	6.72E-07	6.97E-10	6.91E-07	8.33E-09	4.23E-09	1.05E-09	1.60E-10
70	4.30E-05	2.87E-05	4.86E-07	1.50E-06	1.02E-06	1.05E-09	1.03E-06	2.17E-08	1.06E-08	2.72E-09	3.63E-10
75	6.62E-05	4.53E-05	7.59E-07	2.44E-06	1.63E-06	1.59E-09	1.61E-06	5.74E-08	2.59E-08	7.31E-09	9.69E-10
80	1.01E-04	7.34E-05	1.24E-06	3.90E-06	2.59E-06	2.63E-09	2.50E-06	1.45E-07	7.17E-08	2.03E-08	2.52E-09
85	1.66E-04	1.28E-04	2.10E-06	6.67E-06	4.66E-06	4.57E-09	4.34E-06	4.73E-07	2.19E-07	6.12E-08	7.73E-09
90	3.17E-04	2.44E-04	4.24E-06	1.29E-05	8.95E-06	8.74E-09	8.11E-06	1.79E-06	9.02E-07	2.21E-07	2.90E-08
95	7.54E-04	6.10E-04	9.62E-06	3.15E-05	2.25E-05	2.18E-08	2.04E-05	1.15E-05	5.91E-06	1.31E-06	1.76E-07
max	4.12E-02	3.99E-02	4.39E-04	2.25E-03	1.56E-03	1.16E-06	4.09E-04	1.31E-03	1.24E-03	2.54E-04	1.72E-05
mean	2.30E-04	2.00E-04	2.57E-06	9.59E-06	6.27E-06	5.59E-09	4.90E-06	4.58E-06	2.82E-06	5.73E-07	6.08E-08
95/50	9.08E+01	1.14E+02	1.01E+02	1.17E+02	1.17E+02	1.01E+02	9.90E+01	2.07E+04	2.39E+04	1.85E+04	1.17E+04
95 - 50	7.46E-04	6.05E-04	9.52E-06	3.12E-05	2.23E-05	2.16E-08	2.02E-05	1.15E-05	5.91E-06	1.31E-06	1.76E-07

[a] Dose directly from primary contamination and air transport.

Note: Any pathway with 50th or 95th percentile dose that is more than 5 percent of the 50th or 95th percentile dose from all pathways, respectively was considered significant in this analysis and is highlighted. Different colors are used in different rows.

Table B-46 Distributions of Peak Total Dose and Peak Pathway Dose Obtained with Probabilistic Calculations for Offsite Resident via Water Transport Scenario Concerning H-3 Contamination (mrem/yr per pCi/g)

Percentile	All pathways	Water release						CZ and air[a]			
		Fish Ingestion	Plant ingestion	Meat ingestion	Milk ingestion	Soil ingestion	Water ingestion	Plant ingestion	Meat ingestion	Milk ingestion	Soil Ingestion
5	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
10	8.68E-15	1.88E-42	4.93E-16	3.75E-16	8.82E-16	7.62E-20	6.06E-15	0.00E+00	0.00E+00	0.00E+00	0.00E+00
15	4.36E-12	5.50E-18	2.52E-13	1.46E-13	3.44E-13	2.60E-17	2.35E-12	1.19E-30	1.13E-33	5.93E-34	2.93E-33
20	2.69E-11	2.01E-14	1.32E-12	7.75E-13	1.81E-12	1.37E-16	1.22E-11	1.59E-21	9.35E-24	2.64E-24	6.77E-21
25	7.52E-11	1.04E-13	3.80E-12	2.32E-12	5.53E-12	4.17E-16	3.70E-11	2.25E-17	3.34E-19	1.49E-19	1.46E-19
30	1.57E-10	3.14E-13	8.07E-12	4.79E-12	1.11E-11	8.79E-16	7.46E-11	7.79E-16	5.04E-17	3.36E-17	7.59E-19
35	2.68E-10	6.31E-13	1.45E-11	9.19E-12	2.09E-11	1.58E-15	1.40E-10	4.42E-15	3.92E-16	3.61E-16	3.01E-18
40	4.51E-10	1.16E-12	2.40E-11	1.44E-11	3.35E-11	2.63E-15	2.24E-10	1.92E-14	1.85E-15	1.62E-15	9.73E-18
45	7.37E-10	1.91E-12	4.08E-11	2.43E-11	5.75E-11	4.51E-15	3.79E-10	6.44E-14	6.39E-15	6.07E-15	2.59E-17
50	1.17E-09	2.97E-12	6.69E-11	3.89E-11	9.05E-11	7.35E-15	6.00E-10	2.15E-13	2.15E-14	1.99E-14	6.99E-17
55	1.91E-09	4.74E-12	1.04E-10	6.24E-11	1.46E-10	1.14E-14	9.86E-10	6.49E-13	5.97E-14	5.58E-14	1.67E-16
60	3.07E-09	7.26E-12	1.66E-10	1.03E-10	2.35E-10	1.84E-14	1.59E-09	1.61E-12	1.66E-13	1.59E-13	4.01E-16
65	4.89E-09	1.18E-11	2.73E-10	1.64E-10	3.87E-10	3.03E-14	2.61E-09	4.17E-12	4.26E-13	4.17E-13	1.03E-15
70	8.38E-09	1.83E-11	4.76E-10	2.75E-10	6.42E-10	4.99E-14	4.26E-09	1.05E-11	1.12E-12	1.09E-12	2.41E-15
75	1.45E-08	2.96E-11	8.30E-10	4.96E-10	1.16E-09	8.90E-14	7.68E-09	2.93E-11	3.34E-12	3.23E-12	6.47E-15
80	2.48E-08	4.95E-11	1.54E-09	8.97E-10	2.06E-09	1.66E-13	1.38E-08	9.11E-11	9.50E-12	9.45E-12	1.82E-14
85	4.72E-08	9.32E-11	3.07E-09	1.75E-09	4.11E-09	3.31E-13	2.72E-08	2.88E-10	3.34E-11	3.16E-11	5.32E-14
90	1.10E-07	1.83E-10	6.83E-09	4.13E-09	9.22E-09	8.45E-13	6.28E-08	1.09E-09	1.18E-10	1.17E-10	2.07E-13
95	3.60E-07	4.96E-10	2.85E-08	1.57E-08	3.49E-08	2.93E-12	2.33E-07	7.56E-09	8.65E-10	7.90E-10	1.23E-12
max	2.18E-05	1.42E-07	2.45E-06	1.05E-06	2.45E-06	2.86E-10	1.68E-05	2.40E-06	1.86E-07	1.59E-07	3.77E-10
mean	1.32E-07	2.38E-10	1.12E-08	6.17E-09	1.41E-08	1.20E-12	9.37E-08	5.89E-09	5.96E-10	5.60E-10	1.07E-12
95/50	3.08E+02	1.67E+02	4.26E+02	4.04E+02	3.86E+02	3.99E+02	3.88E+02	3.52E+04	4.02E+04	3.97E+04	1.76E+04
95 - 50	3.59E-07	4.93E-10	2.84E-08	1.57E-08	3.48E-08	2.92E-12	2.32E-07	7.56E-09	8.65E-10	7.90E-10	1.23E-12

[a] Dose directly from primary contamination and air transport.

Note: Any pathway with 50th or 95th percentile dose that is more than 5 percent of the 50th or 95th percentile dose from all pathways, respectively was considered significant in this analysis and is highlighted. Different colors are used in different rows.

Table B-47 Distributions of Peak Total Dose and Peak Pathway Dose Obtained with Probabilistic Calculations for Offsite Resident via Water Transport Scenario Concerning I-129 Contamination (mrem/yr per pCi/g)

Percentile	All pathways	Water release						CZ and air[a]			
		Fish Ingestion	Plant ingestion	Meat ingestion	Milk ingestion	Soil ingestion	Water ingestion	Plant ingestion	Meat ingestion	Milk ingestion	Soil ingestion
5	3.54E-07	6.67E-13	3.25E-08	1.94E-08	6.02E-08	3.53E-11	8.63E-08	1.43E-23	7.22E-27	4.80E-27	2.14E-23
10	1.10E-05	8.97E-08	7.70E-07	5.63E-07	1.90E-06	8.40E-10	1.99E-06	1.02E-16	6.22E-19	2.46E-19	2.67E-14
15	3.81E-05	5.95E-07	2.79E-06	2.12E-06	6.76E-06	2.82E-09	6.46E-06	5.86E-13	1.08E-14	6.51E-15	3.48E-13
20	9.03E-05	1.58E-06	7.04E-06	5.76E-06	1.79E-05	7.35E-09	1.68E-05	1.80E-11	1.51E-12	1.29E-12	1.61E-12
25	1.81E-04	3.31E-06	1.44E-05	1.21E-05	3.77E-05	1.45E-08	3.39E-05	1.10E-10	1.22E-11	1.34E-11	5.82E-12
30	3.40E-04	5.90E-06	2.86E-05	2.54E-05	7.33E-05	2.92E-08	6.81E-05	4.43E-10	5.18E-11	6.20E-11	1.76E-11
35	6.66E-04	9.86E-06	5.58E-05	4.86E-05	1.41E-04	5.42E-08	1.31E-04	1.62E-09	1.87E-10	2.35E-10	4.21E-11
40	1.12E-03	1.59E-05	1.03E-04	9.76E-05	2.68E-04	1.01E-07	2.42E-04	4.57E-09	5.51E-10	7.08E-10	9.30E-11
45	1.99E-03	2.41E-05	1.90E-04	1.75E-04	5.03E-04	1.88E-07	4.44E-04	1.05E-08	1.27E-09	1.82E-09	2.04E-10
50	3.61E-03	3.44E-05	3.63E-04	3.53E-04	9.08E-04	3.50E-07	8.60E-04	2.45E-08	3.10E-09	4.26E-09	4.33E-10
55	6.85E-03	5.20E-05	7.32E-04	7.02E-04	1.98E-03	7.27E-07	1.69E-03	5.51E-08	7.54E-09	9.94E-09	9.61E-10
60	1.34E-02	7.52E-05	1.51E-03	1.45E-03	3.93E-03	1.51E-06	3.55E-03	1.32E-07	1.75E-08	2.38E-08	2.06E-09
65	2.78E-02	1.12E-04	3.16E-03	2.98E-03	8.01E-03	3.07E-06	7.43E-03	2.90E-07	4.43E-08	5.64E-08	4.52E-09
70	5.36E-02	1.61E-04	6.21E-03	6.09E-03	1.69E-02	6.51E-06	1.50E-02	6.86E-07	1.07E-07	1.45E-07	9.94E-09
75	1.02E-01	2.41E-04	1.26E-02	1.19E-02	3.32E-02	1.30E-05	3.05E-02	1.77E-06	2.84E-07	3.55E-07	2.56E-08
80	2.01E-01	3.59E-04	2.49E-02	2.26E-02	6.25E-02	2.58E-05	5.78E-02	5.11E-06	7.93E-07	1.06E-06	6.78E-08
85	3.89E-01	5.35E-04	4.94E-02	4.51E-02	1.30E-01	4.90E-05	1.13E-01	1.55E-05	2.41E-06	2.97E-06	1.80E-07
90	7.96E-01	8.98E-04	9.92E-02	1.01E-01	2.94E-01	1.02E-04	2.26E-01	5.27E-05	8.24E-06	1.14E-05	6.76E-07
95	1.84E+00	1.90E-03	2.21E-01	2.95E-01	7.00E-01	2.42E-04	5.28E-01	2.69E-04	5.14E-05	6.09E-05	3.34E-06
max	2.20E+01	5.15E-02	1.92E+00	1.37E+01	1.39E+01	2.03E-03	3.93E+00	1.34E-02	1.07E-02	1.41E-02	1.23E-04
mean	3.59E-01	4.12E-04	3.95E-02	7.97E-02	1.50E-01	4.12E-05	9.02E-02	9.54E-05	2.40E-05	3.09E-05	1.02E-06
95/50	5.10E+02	5.52E+01	6.09E+02	8.36E+02	7.71E+02	6.91E+02	6.14E+02	1.10E+04	1.66E+04	1.43E+04	7.71E+03
95 - 50	1.84E+00	1.87E-03	2.21E-01	2.95E-01	6.99E-01	2.42E-04	5.27E-01	2.69E-04	5.14E-05	6.09E-05	3.34E-06

[a] Dose directly from primary contamination and air transport.

Note: Any pathway with 50th or 95th percentile dose that is more than 5 percent of the 50th or 95th percentile dose from all pathways, respectively was considered significant in this analysis and is highlighted. Different colors are used in different rows.

Table B-48 Distributions of Peak Total Dose and Peak Pathway Dose Obtained with Probabilistic Calculations for Offsite Resident via Water Transport Scenario Concerning Np-237 Contamination (mrem/yr per pCi/g)

Percentile	All pathways	Water release						CZ and air[a]			
		Fish Ingestion	Plant ingestion	Meat ingestion	Milk ingestion	Soil ingestion	Water ingestion	Plant ingestion	Meat ingestion	Milk ingestion	Soil Ingestion
5	5.27E-10	1.40E-14	1.02E-11	6.80E-12	1.30E-13	3.08E-14	2.08E-11	6.14E-21	1.02E-21	1.15E-23	1.71E-22
10	6.20E-06	8.62E-07	1.53E-07	3.00E-08	7.96E-10	5.73E-10	3.10E-07	8.56E-13	3.47E-13	1.53E-15	1.57E-13
15	3.34E-05	8.82E-06	7.47E-07	1.50E-07	3.71E-09	2.75E-09	1.57E-06	1.71E-11	8.09E-12	4.02E-14	1.74E-12
20	8.62E-05	2.66E-05	2.04E-06	3.66E-07	1.01E-08	7.06E-09	4.11E-06	9.24E-11	4.96E-11	2.29E-13	8.07E-12
25	1.72E-04	5.83E-05	4.13E-06	7.88E-07	2.10E-08	1.50E-08	8.78E-06	4.03E-10	1.45E-10	7.20E-13	2.58E-11
30	2.99E-04	1.10E-04	7.86E-06	1.50E-06	3.72E-08	2.78E-08	1.56E-05	1.30E-09	3.83E-10	1.80E-12	7.19E-11
35	4.87E-04	1.86E-04	1.27E-05	2.47E-06	6.77E-08	4.68E-08	2.63E-05	3.31E-09	8.45E-10	4.09E-12	1.82E-10
40	7.85E-04	2.89E-04	2.12E-05	4.19E-06	1.07E-07	7.47E-08	4.32E-05	8.18E-09	1.75E-09	9.55E-12	4.09E-10
45	1.19E-03	4.38E-04	3.38E-05	6.61E-06	1.74E-07	1.24E-07	7.01E-05	1.95E-08	3.65E-09	2.06E-11	9.30E-10
50	1.85E-03	6.72E-04	5.52E-05	1.05E-05	2.72E-07	1.90E-07	1.11E-04	4.54E-08	8.27E-09	4.55E-11	1.93E-09
55	2.80E-03	9.73E-04	8.77E-05	1.69E-05	4.40E-07	2.96E-07	1.80E-04	1.07E-07	1.84E-08	1.03E-10	4.38E-09
60	4.16E-03	1.40E-03	1.38E-04	2.64E-05	7.09E-07	4.60E-07	2.74E-04	2.35E-07	3.93E-08	2.32E-10	9.49E-09
65	6.36E-03	2.03E-03	2.29E-04	4.47E-05	1.17E-06	7.78E-07	4.64E-04	5.78E-07	8.76E-08	4.94E-10	2.25E-08
70	9.98E-03	2.96E-03	3.97E-04	8.35E-05	2.17E-06	1.40E-06	8.43E-04	1.48E-06	2.10E-07	1.14E-09	5.47E-08
75	1.57E-02	4.22E-03	7.81E-04	1.71E-04	4.78E-06	3.07E-06	1.61E-03	3.78E-06	4.83E-07	2.82E-09	1.32E-07
80	2.63E-02	6.31E-03	2.02E-03	4.53E-04	1.20E-05	7.50E-06	3.98E-03	1.00E-05	1.22E-06	7.21E-09	3.43E-07
85	4.84E-02	9.65E-03	5.90E-03	1.67E-03	3.76E-05	2.53E-05	1.17E-02	3.35E-05	2.87E-06	2.02E-08	1.01E-06
90	8.95E-02	1.63E-02	1.81E-02	6.07E-03	1.19E-04	7.46E-05	3.54E-02	1.07E-04	9.03E-06	6.18E-08	3.27E-06
95	2.09E-01	3.28E-02	5.73E-02	2.05E-02	3.50E-04	2.46E-04	1.05E-01	5.51E-04	3.46E-05	2.83E-07	1.58E-05
max	5.20E+00	7.78E-01	1.61E+00	5.48E-01	1.54E-02	9.87E-03	3.30E+00	1.62E-01	1.22E-03	1.12E-05	8.79E-04
mean	4.57E-02	7.34E-03	1.24E-02	4.23E-03	7.89E-05	5.03E-05	2.30E-02	2.20E-04	9.20E-06	8.62E-08	4.42E-06
95/50	1.13E+02	4.88E+01	1.04E+03	1.95E+03	1.29E+03	1.29E+03	9.46E+02	1.21E+04	4.18E+03	6.22E+03	8.19E+03
95 - 50	2.07E-01	3.21E-02	5.72E-02	2.05E-02	3.50E-04	2.46E-04	1.05E-01	5.51E-04	3.46E-05	2.83E-07	1.58E-05

[a] Dose directly from primary contamination and air transport.

Note: Any pathway with 50th or 95th percentile dose that is more than 5 percent of the 50th or 95th percentile dose from all pathways, respectively was considered significant in this analysis and is highlighted. Different colors are used in different rows.

Table B-49 Distributions of Peak Total Dose and Peak Pathway Dose Obtained with Probabilistic Calculations for Offsite Resident via Water Transport Scenario Concerning Pu-239 Contamination (mrem/yr per pCi/g)

Percentile	All pathways	Water release						CZ and air[a]			
		Fish Ingestion	Plant ingestion	Meat ingestion	Milk ingestion	Soil ingestion	Water ingestion	Plant ingestion	Meat ingestion	Milk ingestion	Soil ingestion
5	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
10	3.29E-06	3.26E-06	7.07E-09	7.78E-13	2.96E-12	9.74E-11	1.67E-08	1.19E-15	7.65E-17	2.47E-18	5.09E-13
15	9.99E-05	9.32E-05	1.65E-07	1.54E-11	8.66E-11	2.83E-09	4.28E-07	1.92E-12	5.66E-15	4.55E-16	1.14E-11
20	3.71E-04	3.40E-04	6.39E-07	5.90E-11	3.09E-10	1.03E-08	1.57E-06	4.13E-11	3.11E-14	4.06E-15	5.98E-11
25	8.10E-04	7.55E-04	1.39E-06	1.46E-10	7.31E-10	2.27E-08	3.39E-06	2.35E-10	1.04E-13	1.91E-14	2.26E-10
30	1.59E-03	1.48E-03	2.80E-06	3.00E-10	1.37E-09	4.28E-08	6.63E-06	1.03E-09	3.07E-13	6.76E-14	6.73E-10
35	2.75E-03	2.58E-03	4.73E-06	5.55E-10	2.35E-09	7.56E-08	1.14E-05	3.12E-09	8.21E-13	2.06E-13	1.75E-09
40	4.39E-03	4.16E-03	7.73E-06	1.04E-09	3.90E-09	1.21E-07	1.88E-05	8.73E-09	1.89E-12	5.24E-13	3.86E-09
45	7.07E-03	6.73E-03	1.15E-05	1.73E-09	6.12E-09	1.86E-07	2.87E-05	2.32E-08	4.07E-12	1.26E-12	7.62E-09
50	1.12E-02	1.09E-02	1.73E-05	2.84E-09	9.36E-09	2.86E-07	4.36E-05	4.94E-08	8.85E-12	2.60E-12	1.59E-08
55	1.67E-02	1.63E-02	2.61E-05	5.04E-09	1.40E-08	4.17E-07	6.46E-05	1.08E-07	1.86E-11	5.86E-12	3.18E-08
60	2.47E-02	2.42E-02	3.84E-05	8.22E-09	2.01E-08	5.90E-07	9.20E-05	2.44E-07	4.34E-11	1.29E-11	7.20E-08
65	3.55E-02	3.49E-02	5.50E-05	1.37E-08	2.88E-08	8.49E-07	1.37E-04	6.04E-07	1.04E-10	3.02E-11	1.58E-07
70	5.29E-02	5.23E-02	8.14E-05	2.44E-08	4.24E-08	1.20E-06	1.98E-04	1.52E-06	2.64E-10	7.69E-11	3.81E-07
75	7.88E-02	7.79E-02	1.20E-04	4.51E-08	6.21E-08	1.70E-06	2.94E-04	3.73E-06	6.23E-10	1.92E-10	9.77E-07
80	1.22E-01	1.22E-01	1.81E-04	9.36E-08	9.66E-08	2.54E-06	4.50E-04	9.71E-06	1.58E-09	4.67E-10	2.41E-06
85	2.08E-01	2.06E-01	3.03E-04	2.05E-07	1.61E-07	3.97E-06	7.23E-04	3.00E-05	4.56E-09	1.48E-09	7.14E-06
90	3.84E-01	3.81E-01	5.23E-04	5.42E-07	2.74E-07	7.26E-06	1.24E-03	1.03E-04	1.59E-08	5.95E-09	2.45E-05
95	9.60E-01	9.55E-01	1.08E-03	2.27E-06	6.74E-07	1.58E-05	2.60E-03	5.25E-04	1.08E-07	2.68E-08	1.17E-04
max	2.55E+01	2.55E+01	2.39E-02	7.50E-04	1.28E-05	2.30E-04	4.17E-02	4.54E-02	3.89E-04	2.96E-06	1.09E-02
mean	2.35E-01	2.33E-01	2.52E-04	1.94E-06	1.42E-07	3.47E-06	6.03E-04	1.82E-04	3.76E-07	1.04E-08	3.52E-05
95/50	8.57E+01	8.76E+01	6.24E+01	7.99E+02	7.20E+01	5.52E+01	5.96E+01	1.06E+04	1.22E+04	1.03E+04	7.36E+03
95 - 50	9.49E-01	9.44E-01	1.06E-03	2.27E-06	6.65E-07	1.55E-05	2.56E-03	5.25E-04	1.08E-07	2.68E-08	1.17E-04

[a] Dose directly from primary contamination and air transport.

Note: Any pathway with 50th or 95th percentile dose that is more than 5 percent of the 50th or 95th percentile dose from all pathways, respectively was considered significant in this analysis and is highlighted. Different colors are used in different rows.

Table B-50 Distributions of Peak Total Dose and Peak Pathway Dose Obtained with Probabilistic Calculations for Offsite Resident via Water Transport Scenario Concerning Ra-226 Contamination (mrem/yr per pCi/g)

Percentile	All pathways	Water release						CZ and air[a]			
		Fish Ingestion	Plant ingestion	Meat ingestion	Milk ingestion	Soil ingestion	Water ingestion	Plant ingestion	Meat ingestion	Milk ingestion	Soil Ingestion
5	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
10	3.44E-05	3.32E-05	7.79E-08	4.49E-08	8.76E-09	2.81E-10	1.92E-07	1.86E-10	1.30E-11	2.06E-12	8.38E-12
15	1.98E-03	1.90E-03	4.18E-06	2.52E-06	5.15E-07	1.37E-08	1.11E-05	1.03E-08	7.18E-10	9.42E-11	4.40E-10
20	8.18E-03	7.73E-03	1.74E-05	1.00E-05	2.07E-06	4.78E-08	4.55E-05	4.52E-08	3.01E-09	4.43E-10	2.10E-09
25	1.96E-02	1.83E-02	4.10E-05	2.42E-05	4.94E-06	1.16E-07	1.09E-04	1.22E-07	8.80E-09	1.25E-09	6.22E-09
30	3.51E-02	3.31E-02	7.78E-05	4.58E-05	9.55E-06	2.21E-07	1.99E-04	2.72E-07	1.99E-08	2.90E-09	1.53E-08
35	6.33E-02	5.91E-02	1.40E-04	8.06E-05	1.65E-05	4.01E-07	3.56E-04	5.56E-07	4.02E-08	5.74E-09	3.59E-08
40	1.03E-01	9.95E-02	2.27E-04	1.30E-04	2.65E-05	6.44E-07	5.91E-04	1.13E-06	7.97E-08	1.19E-08	7.28E-08
45	1.53E-01	1.48E-01	3.35E-04	2.00E-04	4.09E-05	9.95E-07	8.70E-04	2.60E-06	1.91E-07	2.93E-08	1.66E-07
50	2.33E-01	2.27E-01	5.21E-04	3.08E-04	6.35E-05	1.49E-06	1.34E-03	5.61E-06	4.22E-07	6.37E-08	3.77E-07
55	3.49E-01	3.43E-01	7.66E-04	4.54E-04	9.46E-05	2.29E-06	2.03E-03	1.27E-05	9.56E-07	1.47E-07	8.21E-07
60	5.11E-01	5.02E-01	1.12E-03	6.78E-04	1.39E-04	3.34E-06	2.97E-03	2.84E-05	2.12E-06	3.03E-07	1.70E-06
65	7.44E-01	7.28E-01	1.67E-03	9.81E-04	2.03E-04	4.77E-06	4.28E-03	6.38E-05	4.53E-06	6.51E-07	3.67E-06
70	1.06E+00	1.04E+00	2.43E-03	1.45E-03	2.97E-04	6.90E-06	6.26E-03	1.40E-04	1.01E-05	1.44E-06	7.83E-06
75	1.60E+00	1.58E+00	3.68E-03	2.20E-03	4.48E-04	1.06E-05	9.35E-03	3.19E-04	2.30E-05	3.33E-06	1.79E-05
80	2.55E+00	2.52E+00	5.66E-03	3.35E-03	6.86E-04	1.56E-05	1.49E-02	7.13E-04	5.45E-05	7.84E-06	4.48E-05
85	4.12E+00	4.06E+00	9.39E-03	5.55E-03	1.14E-03	2.47E-05	2.40E-02	1.89E-03	1.23E-04	1.86E-05	1.22E-04
90	7.35E+00	7.27E+00	1.73E-02	9.97E-03	2.04E-03	4.75E-05	4.30E-02	5.10E-03	3.42E-04	5.32E-05	3.81E-04
95	1.73E+01	1.71E+01	3.86E-02	2.27E-02	4.64E-03	1.12E-04	1.00E-01	1.61E-02	1.27E-03	1.76E-04	1.44E-03
max	4.78E+02	4.73E+02	1.49E+00	7.18E-01	1.59E-01	1.67E-03	2.73E+00	6.21E-01	5.59E-02	9.55E-03	7.26E-02
mean	4.02E+00	3.97E+00	9.40E-03	5.46E-03	1.12E-03	2.46E-05	2.33E-02	3.93E-03	2.80E-04	4.12E-05	3.91E-04
95/50	7.42E+01	7.53E+01	7.41E+01	7.37E+01	7.31E+01	7.52E+01	7.46E+01	2.87E+03	3.01E+03	2.76E+03	3.82E+03
95 - 50	1.71E+01	1.69E+01	3.81E-02	2.24E-02	4.58E-03	1.11E-04	9.87E-02	1.61E-02	1.27E-03	1.76E-04	1.44E-03

[a] Dose directly from primary contamination and air transport.

Note: Any pathway with 50th or 95th percentile dose that is more than 5 percent of the 50th or 95th percentile dose from all pathways, respectively was considered significant in this analysis and is highlighted. Different colors are used in different rows.

Table B-51 Distributions of Peak Total Dose and Peak Pathway Dose Obtained with Probabilistic Calculations for Offsite Resident via Water Transport Scenario Concerning Ra-228 Contamination (mrem/yr per pCi/g)

Percentile	All pathways	Water release						CZ and air[a]			
		Fish Ingestion	Plant ingestion	Meat ingestion	Milk ingestion	Soil ingestion	Water ingestion	Plant ingestion	Meat ingestion	Milk ingestion	Soil ingestion
5	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
10	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
15	3.81E-15	3.35E-15	7.51E-17	9.28E-18	1.04E-17	4.12E-20	1.60E-16	4.46E-19	3.70E-21	7.98E-22	9.14E-21
20	1.69E-09	1.21E-09	2.49E-11	2.81E-12	3.12E-12	1.47E-14	5.94E-11	6.39E-14	5.96E-16	1.52E-16	5.80E-16
25	1.22E-08	8.64E-09	1.65E-10	1.83E-11	2.57E-11	1.01E-13	4.21E-10	1.17E-12	1.37E-14	3.22E-15	7.49E-15
30	4.31E-08	2.90E-08	5.79E-10	6.38E-11	8.24E-11	3.19E-13	1.38E-09	7.37E-12	7.80E-14	2.15E-14	4.19E-14
35	1.02E-07	7.17E-08	1.46E-09	1.68E-10	1.93E-10	7.88E-13	3.51E-09	2.86E-11	3.32E-13	9.37E-14	1.70E-13
40	2.29E-07	1.62E-07	3.25E-09	3.73E-10	4.53E-10	1.85E-12	7.79E-09	9.29E-11	1.13E-12	3.87E-13	5.94E-13
45	4.84E-07	3.57E-07	7.07E-09	8.73E-10	1.06E-09	3.99E-12	1.74E-08	2.75E-10	3.40E-12	1.23E-12	1.62E-12
50	1.05E-06	7.79E-07	1.59E-08	1.89E-09	2.37E-09	9.15E-12	3.78E-08	7.67E-10	9.67E-12	3.41E-12	4.10E-12
55	2.33E-06	1.69E-06	3.45E-08	3.93E-09	5.09E-09	1.96E-11	8.20E-08	1.96E-09	2.43E-11	8.92E-12	1.07E-11
60	4.78E-06	3.55E-06	7.15E-08	8.23E-09	1.02E-08	4.09E-11	1.73E-07	5.14E-09	6.21E-11	2.45E-11	2.69E-11
65	1.05E-05	7.57E-06	1.49E-07	1.85E-08	2.34E-08	9.01E-11	3.65E-07	1.28E-08	1.72E-10	6.66E-11	7.39E-11
70	2.30E-05	1.68E-05	3.35E-07	3.97E-08	4.95E-08	2.00E-10	8.05E-07	3.83E-08	4.58E-10	1.97E-10	1.82E-10
75	4.91E-05	3.55E-05	7.18E-07	8.73E-08	9.91E-08	4.17E-10	1.73E-06	9.44E-08	1.27E-09	5.61E-10	4.90E-10
80	1.08E-04	7.93E-05	1.64E-06	1.85E-07	2.31E-07	8.75E-10	3.86E-06	2.73E-07	3.87E-09	1.81E-09	1.51E-09
85	2.50E-04	1.92E-04	3.94E-06	4.59E-07	5.87E-07	2.22E-09	9.35E-06	1.03E-06	1.38E-08	6.42E-09	5.49E-09
90	6.46E-04	4.88E-04	9.78E-06	1.29E-06	1.77E-06	5.91E-09	2.37E-05	4.83E-06	6.67E-08	3.14E-08	2.54E-08
95	2.99E-03	2.45E-03	4.90E-05	5.93E-06	8.02E-06	2.81E-08	1.18E-04	3.56E-05	5.85E-07	2.67E-07	1.66E-07
max	2.66E-01	2.46E-01	5.78E-03	6.33E-04	1.84E-03	6.69E-06	1.15E-02	5.83E-02	9.00E-04	4.19E-04	4.68E-04
mean	9.92E-04	8.67E-04	1.79E-05	2.39E-06	3.45E-06	1.20E-08	4.14E-05	6.54E-05	1.28E-06	8.37E-07	3.71E-07
95/50	2.85E+03	3.15E+03	3.08E+03	3.14E+03	3.38E+03	3.07E+03	3.12E+03	4.64E+04	6.05E+04	7.83E+04	4.05E+04
95 - 50	2.99E-03	2.45E-03	4.90E-05	5.93E-06	8.02E-06	2.81E-08	1.18E-04	3.56E-05	5.85E-07	2.67E-07	1.66E-07

[a] Dose directly from primary contamination and air transport.

Note: Any pathway with 50th or 95th percentile dose that is more than 5 percent of the 50th or 95th percentile dose from all pathways, respectively was considered significant in this analysis and is highlighted. Different colors are used in different rows.

Table B-52 Distributions of Peak Total Dose and Peak Pathway Dose Obtained with Probabilistic Calculations for Offsite Resident via Water Transport Scenario Concerning Sr-90 Contamination (mrem/yr per pCi/g)

Percentile	All pathways	Water release						CZ and air[a]			
		Fish Ingestion	Plant ingestion	Meat ingestion	Milk ingestion	Soil ingestion	Water ingestion	Plant ingestion	Meat ingestion	Milk ingestion	Soil Ingestion
5	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
10	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
15	1.05E-08	1.52E-09	1.65E-09	1.84E-10	6.09E-10	1.45E-12	2.47E-09	1.21E-18	2.13E-23	9.05E-24	2.43E-15
20	1.22E-07	1.84E-08	2.06E-08	2.14E-09	7.66E-09	1.80E-11	2.82E-08	3.38E-13	1.09E-15	5.45E-16	3.81E-14
25	4.17E-07	5.85E-08	6.00E-08	6.74E-09	2.31E-08	5.49E-11	8.84E-08	1.01E-11	1.27E-13	1.27E-13	1.92E-13
30	8.63E-07	1.24E-07	1.35E-07	1.39E-08	5.07E-08	1.06E-10	1.81E-07	6.13E-11	1.02E-12	9.63E-13	6.53E-13
35	1.61E-06	2.18E-07	2.52E-07	2.65E-08	8.88E-08	1.99E-10	3.25E-07	2.22E-10	4.89E-12	4.76E-12	2.15E-12
40	2.69E-06	3.74E-07	4.06E-07	4.57E-08	1.44E-07	3.40E-10	5.45E-07	8.38E-10	1.87E-11	1.76E-11	5.50E-12
45	4.16E-06	5.78E-07	6.62E-07	7.55E-08	2.37E-07	5.57E-10	8.43E-07	2.31E-09	5.31E-11	5.11E-11	1.23E-11
50	6.46E-06	9.03E-07	9.90E-07	1.15E-07	3.67E-07	8.09E-10	1.32E-06	5.40E-09	1.37E-10	1.28E-10	3.03E-11
55	9.51E-06	1.37E-06	1.46E-06	1.82E-07	5.68E-07	1.21E-09	2.01E-06	1.36E-08	3.40E-10	2.90E-10	6.71E-11
60	1.37E-05	2.04E-06	2.28E-06	2.84E-07	8.47E-07	1.82E-09	2.99E-06	3.44E-08	8.52E-10	7.73E-10	1.60E-10
65	2.11E-05	2.96E-06	3.60E-06	4.32E-07	1.28E-06	2.67E-09	4.32E-06	8.70E-08	2.09E-09	2.19E-09	3.56E-10
70	3.10E-05	4.50E-06	5.24E-06	6.96E-07	1.95E-06	3.92E-09	6.65E-06	2.18E-07	5.53E-09	5.56E-09	8.37E-10
75	4.90E-05	6.93E-06	7.88E-06	1.09E-06	2.98E-06	6.27E-09	1.01E-05	5.70E-07	1.43E-08	1.47E-08	2.16E-09
80	7.52E-05	1.08E-05	1.28E-05	1.76E-06	4.86E-06	9.63E-09	1.58E-05	1.50E-06	4.34E-08	3.55E-08	5.11E-09
85	1.31E-04	1.75E-05	2.17E-05	3.12E-06	7.90E-06	1.60E-08	2.57E-05	4.41E-06	1.21E-07	1.11E-07	1.51E-08
90	2.52E-04	3.28E-05	4.43E-05	6.03E-06	1.48E-05	3.08E-08	4.82E-05	1.86E-05	4.41E-07	4.62E-07	5.75E-08
95	5.64E-04	8.53E-05	1.09E-04	1.75E-05	3.55E-05	7.49E-08	1.21E-04	9.67E-05	3.03E-06	2.85E-06	3.04E-07
max	4.04E-02	6.58E-03	5.34E-03	2.48E-03	3.32E-03	1.37E-05	7.82E-03	4.02E-02	9.97E-04	4.65E-04	1.94E-05
mean	1.48E-04	2.22E-05	2.72E-05	5.48E-06	1.01E-05	2.05E-08	3.05E-05	5.67E-05	1.70E-06	1.11E-06	1.06E-07
95/50	8.73E+01	9.45E+01	1.10E+02	1.52E+02	9.67E+01	9.26E+01	9.17E+01	1.79E+04	2.21E+04	2.23E+04	1.00E+04
95 - 50	5.58E-04	8.44E-05	1.08E-04	1.74E-05	3.51E-05	7.41E-08	1.20E-04	9.67E-05	3.03E-06	2.85E-06	3.04E-07

[a] Dose directly from primary contamination and air transport.

Note: Any pathway with 50th or 95th percentile dose that is more than 5 percent of the 50th or 95th percentile dose from all pathways, respectively was considered significant in this analysis and is highlighted. Different colors are used in different rows.

Table B-53 Distributions of Peak Total Dose and Peak Pathway Dose Obtained with Probabilistic Calculations for Offsite Resident via Water Transport Scenario Concerning Tc-99 Contamination (mrem/yr per pCi/g)

Percentile	All pathways	Water release						CZ and air[a]			
		Fish Ingestion	Plant ingestion	Meat ingestion	Milk ingestion	Soil ingestion	Water ingestion	Plant ingestion	Meat ingestion	Milk ingestion	Soil Ingestion
5	3.59E-09	0.00E+00	6.58E-10	6.49E-12	2.15E-10	2.21E-14	9.55E-10	0.00E+00	0.00E+00	0.00E+00	0.00E+00
10	7.64E-08	3.64E-10	1.31E-08	1.36E-10	3.92E-09	4.43E-13	2.05E-08	8.83E-21	8.62E-27	2.29E-26	4.87E-18
15	2.72E-07	2.28E-09	4.95E-08	4.98E-10	1.48E-08	1.52E-12	7.41E-08	1.14E-14	1.85E-18	6.48E-18	9.61E-17
20	7.16E-07	6.21E-09	1.30E-07	1.35E-09	4.07E-08	3.95E-12	1.91E-07	4.75E-13	6.41E-16	5.19E-15	5.86E-16
25	1.70E-06	1.40E-08	3.06E-07	3.00E-09	9.83E-08	9.16E-12	4.26E-07	3.31E-12	4.31E-15	3.91E-14	2.26E-15
30	3.38E-06	2.52E-08	6.37E-07	6.54E-09	1.96E-07	1.97E-11	9.25E-07	1.45E-11	2.21E-14	2.29E-13	6.25E-15
35	6.53E-06	4.38E-08	1.33E-06	1.50E-08	4.32E-07	4.11E-11	1.91E-06	4.49E-11	7.32E-14	7.25E-13	1.60E-14
40	1.27E-05	7.43E-08	2.82E-06	3.18E-08	9.14E-07	8.60E-11	3.97E-06	1.18E-10	1.90E-13	2.02E-12	3.54E-14
45	2.62E-05	1.26E-07	6.36E-06	6.96E-08	2.24E-06	1.96E-10	8.97E-06	2.73E-10	4.70E-13	5.18E-12	7.77E-14
50	6.04E-05	1.95E-07	1.70E-05	1.60E-07	5.09E-06	4.84E-10	2.23E-05	6.55E-10	1.06E-12	1.25E-11	1.74E-13
55	1.35E-04	3.06E-07	4.14E-05	4.41E-07	1.34E-05	1.23E-09	5.87E-05	1.61E-09	2.77E-12	3.20E-11	3.68E-13
60	3.38E-04	4.72E-07	1.13E-04	1.16E-06	3.61E-05	3.49E-09	1.62E-04	3.77E-09	6.51E-12	7.02E-11	8.50E-13
65	8.04E-04	7.50E-07	2.66E-04	3.03E-06	8.51E-05	8.35E-09	3.97E-04	8.96E-09	1.67E-11	1.70E-10	1.78E-12
70	1.73E-03	1.20E-06	6.18E-04	6.25E-06	1.75E-04	1.76E-08	8.40E-04	2.05E-08	4.06E-11	3.94E-10	4.14E-12
75	3.48E-03	1.90E-06	1.18E-03	1.20E-05	3.41E-04	3.50E-08	1.66E-03	5.25E-08	9.53E-11	9.84E-10	9.74E-12
80	6.11E-03	2.94E-06	2.10E-03	2.19E-05	6.29E-04	6.66E-08	3.06E-03	1.40E-07	2.63E-10	2.62E-09	2.51E-11
85	1.04E-02	5.02E-06	3.60E-03	3.79E-05	1.10E-03	1.11E-07	5.18E-03	4.36E-07	8.05E-10	9.23E-09	7.59E-11
90	1.75E-02	8.79E-06	6.26E-03	6.46E-05	2.00E-03	1.90E-07	8.36E-03	1.74E-06	3.54E-09	3.61E-08	2.48E-10
95	3.07E-02	1.87E-05	1.10E-02	1.27E-04	3.98E-03	3.15E-07	1.45E-02	8.98E-06	1.75E-08	1.85E-07	1.33E-09
max	1.34E-01	6.45E-04	8.94E-02	1.17E-03	3.79E-02	1.47E-06	5.49E-02	7.31E-04	1.49E-06	1.79E-05	7.91E-08
mean	5.18E-03	3.98E-06	1.98E-03	2.26E-05	7.31E-04	5.54E-08	2.44E-03	2.99E-06	6.40E-09	7.13E-08	3.94E-10
95/50	5.08E+02	9.59E+01	6.47E+02	7.94E+02	7.82E+02	6.51E+02	6.50E+02	1.37E+04	1.65E+04	1.48E+04	7.64E+03
95 - 50	3.06E-02	1.85E-05	1.10E-02	1.27E-04	3.97E-03	3.15E-07	1.45E-02	8.98E-06	1.75E-08	1.85E-07	1.33E-09

[a] Dose directly from primary contamination and air transport.

Note: Any pathway with 50th or 95th percentile dose that is more than 5 percent of the 50th or 95th percentile dose from all pathways, respectively was considered significant in this analysis and is highlighted. Different colors are used in different rows.

Table B-54 Distributions of Peak Total Dose and Peak Pathway Dose Obtained with Probabilistic Calculations for Offsite Resident via Water Transport Scenario Concerning U-238 Contamination (mrem/yr per pCi/g)

Percentile	All pathways	Water release						CZ and air[a]			
		Fish Ingestion	Plant ingestion	Meat ingestion	Milk ingestion	Soil Ingestion	Water ingestion	Plant ingestion	Meat ingestion	Milk ingestion	Soil Ingestion
5	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
10	4.24E-07	2.96E-09	1.44E-09	2.50E-07	1.15E-09	1.44E-11	3.85E-09	8.49E-15	2.39E-15	8.89E-17	5.46E-14
15	1.64E-05	1.58E-07	6.59E-08	9.81E-06	4.16E-08	4.71E-10	1.72E-07	1.80E-12	3.85E-12	2.94E-14	1.05E-12
20	5.16E-05	5.46E-07	2.28E-07	3.22E-05	1.51E-07	1.58E-09	5.81E-07	1.41E-11	2.58E-10	6.86E-13	5.65E-12
25	1.18E-04	1.22E-06	5.07E-07	7.01E-05	3.57E-07	3.34E-09	1.26E-06	6.97E-11	2.19E-09	5.08E-12	2.17E-11
30	2.16E-04	2.33E-06	9.55E-07	1.36E-04	7.11E-07	6.34E-09	2.34E-06	2.56E-10	1.01E-08	1.85E-11	6.19E-11
35	3.89E-04	4.01E-06	1.62E-06	2.30E-04	1.20E-06	1.05E-08	4.04E-06	7.46E-10	3.74E-08	6.12E-11	1.48E-10
40	5.84E-04	6.24E-06	2.53E-06	3.75E-04	2.03E-06	1.64E-08	6.41E-06	1.99E-09	1.03E-07	1.84E-10	3.56E-10
45	8.78E-04	9.32E-06	3.82E-06	5.61E-04	3.39E-06	2.46E-08	9.54E-06	5.30E-09	2.74E-07	4.87E-10	7.84E-10
50	1.34E-03	1.35E-05	5.58E-06	8.41E-04	5.34E-06	3.62E-08	1.38E-05	1.22E-08	6.95E-07	1.25E-09	1.64E-09
55	2.03E-03	2.01E-05	8.25E-06	1.28E-03	8.19E-06	5.38E-08	2.06E-05	2.77E-08	1.60E-06	2.97E-09	3.81E-09
60	2.85E-03	2.90E-05	1.19E-05	1.90E-03	1.18E-05	7.84E-08	2.93E-05	6.40E-08	3.78E-06	7.22E-09	7.81E-09
65	4.15E-03	4.40E-05	1.79E-05	2.77E-03	1.74E-05	1.15E-07	4.44E-05	1.56E-07	9.45E-06	1.77E-08	1.87E-08
70	6.14E-03	6.60E-05	2.65E-05	4.22E-03	2.70E-05	1.69E-07	6.73E-05	3.90E-07	2.19E-05	4.54E-08	4.01E-08
75	9.03E-03	9.69E-05	4.04E-05	6.20E-03	4.25E-05	2.52E-07	9.97E-05	9.03E-07	5.45E-05	1.14E-07	9.70E-08
80	1.40E-02	1.48E-04	6.14E-05	9.44E-03	6.86E-05	3.69E-07	1.51E-04	2.46E-06	1.46E-04	3.01E-07	2.55E-07
85	2.24E-02	2.34E-04	9.59E-05	1.61E-02	1.16E-04	5.78E-07	2.40E-04	7.67E-06	4.47E-04	9.29E-07	8.18E-07
90	3.89E-02	4.04E-04	1.73E-04	2.78E-02	2.46E-04	1.04E-06	4.22E-04	2.60E-05	1.65E-03	3.69E-06	2.69E-06
95	8.89E-02	9.22E-04	4.09E-04	6.77E-02	6.73E-04	2.54E-06	1.00E-03	1.45E-04	9.36E-03	2.09E-05	1.31E-05
max	4.34E+01	1.50E-01	2.87E-01	4.20E+01	1.31E+00	5.38E-03	6.78E-01	6.42E-03	1.69E+00	4.05E-03	8.56E-04
mean	6.17E-02	2.60E-04	3.67E-04	5.58E-02	1.00E-03	4.98E-06	8.28E-04	4.90E-05	3.69E-03	1.12E-05	4.15E-06
95/50	6.63E+01	6.83E+01	7.33E+01	8.05E+01	1.26E+02	7.02E+01	7.25E+01	1.19E+04	1.35E+04	1.67E+04	7.99E+03
95 - 50	8.76E-02	9.09E-04	4.03E-04	6.69E-02	6.68E-04	2.50E-06	9.86E-04	1.45E-04	9.36E-03	2.09E-05	1.31E-05

[a] Dose directly from primary contamination and air transport.

Note: Any pathway with 50th or 95th percentile dose that is more than 5 percent of the 50th or 95th percentile dose from all pathways, respectively was considered significant in this analysis and is highlighted. Different colors are used in different rows.

Table B-55 Dominant Exposure Pathways at the 50th and 95th Dose Percentiles for Offsite Resident via Water Transport Scenario

Radionuclide	Table	Percentile		Comments
		50	95	
C-14	B-43	Fish (Water) Plant (CZ and air) Meat (CZ and air)	Fish (Water) Plant (CZ and air)	The absolute dose variability in the peak total dose is mainly associated with variability in fish ingestion pathway as shown in the last row in Table B-43.
Co-60	B-44	Fish (Water) Water (Water) Plant (Water)	Fish (Water) Water (Water) Plant (Water)	The absolute dose variability in the peak dose is mainly associated with variability in fish ingestion, water ingestion, and plant ingestion pathways as shown in the last row in Table B-44.
Cs-137	B-45	Fish (Water)	Fish (Water)	The absolute dose variability in the peak dose is mainly associated with variability in fish ingestion pathway as shown in the last row in Table B-45.
H-3	B-46	Water (Water) Plant (Water) Milk (Water)	Water (Water) Plant (Water) Meat (Water) Milk (Water)	The absolute dose variability in the peak dose is associated with variability in water ingestion, milk ingestion, plant ingestion, and meat ingestion pathways as shown in the last row in Table B-46.
I-129	B-47	Milk (Water) Water (Water) Plant (Water) Meat (Water)	Milk (Water) Water (Water) Plant (Water) Meat (Water)	The absolute dose variability in the peak dose is associated with variability in milk ingestion, water ingestion, meat ingestion, and plant ingestion pathways as shown in the last row in Table B-47.
Np-237	B-48	Fish (Water) Water (Water)	Fish (Water) Water (Water) Plant (Water) Meat (Water)	The absolute dose variability in the peak dose is associated with variability in water ingestion, plant ingestion, fish ingestion, and meat ingestion pathways as shown in the last row in Table B-48.
Pu-239	B-49	Fish (Water)	Fish (Water)	The absolute dose variability in the peak dose is mainly associated with variability in fish ingestion pathway as shown in the last row in Table B-49.
Ra-226	B-50	Fish (Water)	Fish (Water)	The absolute dose variability in the peak dose is mainly associated with variability in fish ingestion pathway as shown in the last row in Table B-50.
Ra-228	B-51	Fish (Water)	Fish (Water)	The absolute dose variability in the peak dose is mainly associated with variability in fish ingestion pathway as shown in the last row in Table B-51.
Sr-90	B-52	Water (Water) Plant (Water) Fish (Water) Milk (Water)	Water (Water) Plant (Water) Plant (CZ and air) Fish (Water) Milk (Water)	The absolute dose variability in the peak dose is associated with variability in water ingestion, plant ingestion, milk ingestion, and fish ingestion pathways as shown in the last row in Table B-52.
Tc-99	B-53	Water (Water) Plant (Water) Milk (Water)	Water (Water) Plant (Water) Milk (Water)	The absolute dose variability in the peak dose is associated with variability in water ingestion, milk ingestion, and plant ingestion pathways as shown in the last row in Table B-53.
U-238	B-54	Meat (Water)	Meat (Water))	The absolute dose variability in the peak dose is mainly associated with variability in meat ingestion pathway as shown in the last row in Table B-54.

Table B-56 Summary of Regression Analysis to Identify Parameters Influencing the Peak Total Dose for the Offsite Resident via Water Transport Scenario

C-14 Regression Coefficients for Peak All Pathways Dose			
Repetition =	1	2	3
Coefficient of determination (R-squared) =	0.75	0.76	0.76
Description of probabilistic variable	SRRC	SRRC	SRRC
Cover and management factor in area of primary contamination	0.44	0.42	0.42
Thickness of cover	-0.41	-0.44	-0.42
Slope-length-steepness factor in area of primary contamination	0.36	0.36	0.37
Water to aquatic food transfer factor of C for Fish	0.22	0.24	0.22
Depth of soil mixing layer in area of primary contamination	0.22	0.22	0.23
Rainfall and runoff factor in area of primary contamination	0.24	0.21	0.22
C-14 evasion flux rate from soil	0.16	0.19	0.16
Dry bulk density of contaminated zone	0.15	0.15	0.14
Runoff coefficient of catchment area	-0.07	-0.1	-0.11
Soil erodibility factor of cover	0.09	0.08	0.08
Thickness of contaminated zone	0.06	0.05	0.06
First time at which release begins	0.06	0.05	0.05
Dry bulk density of cover	-0.03	-0.04	-0.05
Co-60 Regression Coefficients for Peak All Pathways Dose			
Repetition =	1	2	3
Coefficient of determination (R-squared) =	0.74	0.75	0.74
Description of probabilistic variable	SRRC	SRRC	SRRC
First time at which release begins	-0.53	-0.56	-0.52
Depth of soil mixing layer in area of primary contamination	0.41	0.38	0.4
Cover and management factor in area of primary contamination	0.3	0.29	0.29
Thickness of cover	-0.26	-0.25	-0.29
Slope-length-steepness factor in area of primary contamination	0.26	0.28	0.26
Rainfall and runoff factor in area of primary contamination	0.14	0.14	0.15
Deposition velocity of all particulates (to compute atmospheric release)	0.06	0.05	0.04
Soil erodibility factor of cover	0.05	0.05	0.03
Cs-137 Regression Coefficients for Peak All Pathways Dose			
Repetition =	1	2	3
Coefficient of determination (R-squared) =	0.77	0.77	0.78
Description of probabilistic variable	SRRC	SRRC	SRRC
Cover and management factor in area of primary contamination	0.49	0.49	0.49
Note: For identifying parameters that impact the peak all pathway dose, a cut-off value of 0.05 was subjectively selected for the SRRC.			

Table B-56 Summary of Regression Analysis to Identify Parameters Influencing the Peak Total Dose for the Offsite Resident via Water Transport Scenario (cont.)

Cs-137 Regression Coefficients for Peak All Pathways Dose (cont.)			
Slope-length-steepness factor in area of primary contamination	0.41	0.43	0.42
Depth of soil mixing layer in area of primary contamination	0.37	0.33	0.35
Thickness of cover	-0.25	-0.24	-0.28
Rainfall and runoff factor in area of primary contamination	0.21	0.21	0.22
Water to aquatic food transfer factor of Cs for Fish	0.18	0.17	0.17
First time at which release begins	-0.14	-0.16	-0.13
Soil erodibility factor of cover	0.08	0.1	0.07
Runoff coefficient of catchment area	-0.06	-0.07	-0.09
Slope-length-steepness factor of catchment area	-0.08	-0.07	-0.07
Cover and management factor of catchment area	-0.06	-0.09	-0.07
Deposition velocity of all particulates (to compute atmospheric release)	0.07	0.08	0.06
Dry bulk density of cover	-0.04	-0.07	-0.06
Fraction of eroded radionuclides deposited in the surface water body	0.05	0.05	0.04
H-3 Regression Coefficients for Peak All Pathways Dose			
Repetition =	1	2	3
Coefficient of determination (R-squared) =	0.6	0.6	0.62
Description of probabilistic Variable	SRRC	SRRC	SRRC
First time at which release begins	-0.35	-0.33	-0.36
Hydraulic Conductivity of saturated zone	0.29	0.29	0.28
Depth of soil mixing layer in area of primary contamination	0.3	0.26	0.27
Cover and management factor in area of primary contamination	0.25	0.28	0.29
Slope-length-steepness factor in area of primary contamination	0.23	0.26	0.24
Hydraulic Gradient of saturated zone to well	0.23	0.23	0.23
Thickness of cover	-0.19	-0.15	-0.18
Rainfall and runoff factor in area of primary contamination	0.14	0.16	0.16
Deposition velocity of all particulates (to compute atmospheric release)	0.11	0.11	0.08
Thickness (meters) of unsaturated zone	-0.06	-0.08	-0.09
Runoff coefficient of catchment area	-0.06	-0.1	-0.07
Soil erodibility factor of cover	0.04	0.03	0.05
Evapotranspiration coefficient in area of primary contamination	-0.03	-0.03	-0.06
Note: For identifying parameters that impact the peak all pathway dose, a cut-off value of 0.05 was subjectively selected for the SRRC.			

Table B-56 Summary of Regression Analysis to Identify Parameters Influencing the Peak Total Dose for the Offsite Resident via Water Transport Scenario (cont.)

I-129 Regression Coefficients for Peak All Pathways Dose			
Repetition =	1	2	3
Coefficient of determination (R-squared) =	0.69	0.71	0.7
Description of probabilistic Variable	SRRC	SRRC	SRRC
Hydraulic conductivity of saturated zone	0.53	0.56	0.54
Hydraulic gradient of saturated zone to well	0.42	0.4	0.42
K_d of I-129 in saturated zone	-0.32	-0.33	-0.32
Cover and management factor in area of primary contamination	0.14	0.16	0.16
Slope-length-steepness factor in area of primary contamination	0.14	0.12	0.12
K_d of I-129 in unsaturated zone	-0.09	-0.09	-0.11
Rainfall and runoff factor in area of primary contamination	0.1	0.08	0.09
Thickness (meters) of unsaturated zone	-0.08	-0.07	-0.07
Intake to animal product transfer factor of I for Milk	0.06	0.06	0.05
Effective porosity of saturated zone	-0.05	-0.05	-0.07
Depth of soil mixing layer in area of primary contamination	0.06	0.06	0.05
Distance in the direction parallel to aquifer flow from downgradient edge of contamination	-0.05	-0.04	-0.07
Runoff coefficient of catchment area	-0.02	-0.07	-0.06
Thickness of cover	-0.04	-0.03	-0.05
Intake to animal product transfer factor of element I for Meat	0.05	0.03	0.05
Total porosity of saturated zone	0.05	0.03	0.04
Thickness of contaminated zone	0.02	0.05	0.04
Np-237 Regression Coefficients for Peak All Pathways Dose			
Repetition =	1	2	3
Coefficient of determination (R-squared) =	0.62	0.61	0.6
Description of probabilistic variable	SRRC	SRRC	SRRC
Cover and management factor in area of primary contamination	0.39	0.35	0.38
Hydraulic conductivity of saturated zone	0.3	0.36	0.31
Slope-length-steepness factor in area of primary contamination	0.33	0.28	0.32
Hydraulic gradient of saturated zone to well	0.23	0.22	0.23
K_d of Np-237 in saturated zone	-0.2	-0.22	-0.23
Rainfall and runoff factor in area of primary contamination	0.21	0.19	0.18
K_d of Np-237 in unsaturated zone	-0.13	-0.15	-0.11
Depth of soil mixing layer in area of primary contamination	0.12	0.13	0.13
Note: For identifying parameters that impact the peak all pathway dose, a cut-off value of 0.05 was subjectively selected for the SRRC.			

Table B-56 Summary of Regression Analysis to Identify Parameters Influencing the Peak Total Dose for the Offsite Resident via Water Transport Scenario (cont.)

Np-237 Regression Coefficients for Peak All Pathways Dose (cont.)			
Thickness (meters) of unsaturated zone	-0.12	-0.12	-0.1
Runoff coefficient of catchment area	-0.09	-0.1	-0.11
Thickness of cover	-0.09	-0.09	-0.11
Soil erodibility factor of cover	0.08	0.06	0.05
Fraction of eroded radionuclides deposited in the surface water body	0.06	0.04	0.04
Distance in the direction parallel to aquifer flow from downgradient edge of contamination	-0.04	-0.06	-0.03
Deposition velocity of all particulates of Np	0.04	0.03	0.06
Pu-239 Regression Coefficients for Peak All Pathways Dose			
Repetition =	1	2	3
Coefficient of determination (R-squared) =	0.81	0.82	0.82
Description of probabilistic variable	SRRC	SRRC	SRRC
Cover and management factor in area of primary contamination	0.57	0.58	0.58
Slope-length-steepness factor in area of primary contamination	0.44	0.45	0.45
Water to aquatic food transfer factor of Pu for fish	0.26	0.26	0.26
Rainfall and runoff factor in area of primary contamination	0.25	0.25	0.25
Depth of soil mixing layer in area of primary contamination	0.24	0.24	0.24
Thickness of cover	-0.19	-0.18	-0.2
Runoff coefficient of catchment area	-0.1	-0.1	-0.11
Soil erodibility factor of cover	0.09	0.11	0.1
Slope-length-steepness factor of catchment area	-0.09	-0.08	-0.09
Cover and management factor of catchment area	-0.07	-0.09	-0.07
Fraction of eroded radionuclides deposited in the surface water body	0.07	0.06	0.06
Dry bulk density of cover	-0.06	-0.06	-0.05
Support practice factor in area of primary contamination	0.03	0.02	0.05
Ra-226 Regression Coefficients for Peak All Pathways Dose			
Repetition =	1	2	3
Coefficient of -determination (R-squared) =	0.81	0.82	0.82
Description of probabilistic variable	SRRC	SRRC	SRRC
Cover and management factor in area of primary contamination	0.57	0.58	0.58
Slope-length-steepness factor in area of primary contamination	0.45	0.46	0.45
Depth of soil mixing layer in area of primary contamination	0.3	0.28	0.29
Rainfall and runoff factor in area of primary contamination	0.24	0.22	0.23

Note: For identifying parameters that impact the peak all pathway dose, a cut-off value of 0.05 was subjectively selected for the SRRC.

Table B-56 Summary of Regression Analysis to Identify Parameters Influencing the Peak Total Dose for the Offsite Resident via Water Transport Scenario (cont.)

Ra-226 Regression Coefficients for Peak All Pathways Dose (cont.)			
Thickness of cover	-0.21	-0.21	-0.23
Runoff coefficient of catchment area	-0.11	-0.13	-0.13
Slope-length-steepness factor of catchment area	-0.12	-0.12	-0.12
Cover and management factor of catchment area	-0.11	-0.14	-0.11
Soil erodibility factor of cover	0.1	0.12	0.1
Fraction of eroded radionuclides deposited in the surface water body	0.08	0.06	0.06
Dry bulk density of cover	-0.06	-0.06	-0.06
First time at which release begins	0.04	0.02	0.05
Ra-228 Regression Coefficients for Peak All Pathways Dose			
Repetition =	1	2	3
Coefficient of determination (R-squared) =	0.75	0.76	0.75
Description of probabilistic variable	SRRC	SRRC	SRRC
First time at which release begins	-0.53	-0.56	-0.52
Depth of soil mixing layer in area of primary contamination	0.41	0.37	0.39
Cover and management factor in area of primary contamination	0.32	0.31	0.31
Slope-length-steepness factor in area of primary contamination	0.27	0.29	0.28
Thickness of cover	-0.26	-0.25	-0.29
Rainfall and runoff factor in area of primary contamination	0.15	0.14	0.15
Soil erodibility factor of cover	0.06	0.07	0.04
Cover and management factor of catchment area	-0.02	-0.05	-0.05
Deposition velocity of all particulates (to compute atmospheric release)	0.05	0.04	0.03
Runoff coefficient of leafy vegetables fields	-0.03	-0.03	-0.05
Sr-90 Regression Coefficients for Peak All Pathways Dose			
Repetition =	1	2	3
Coefficient of determination (R-squared) =	0.72	0.73	0.73
Description of probabilistic variable	SRRC	SRRC	SRRC
Cover and management factor in area of primary contamination	0.46	0.46	0.45
Slope-length-steepness factor in area of primary contamination	0.39	0.4	0.4
Depth of soil mixing layer in area of primary contamination	0.37	0.33	0.36
Thickness of cover	-0.24	-0.24	-0.27
Rainfall and runoff factor in area of primary contamination	0.23	0.23	0.24
First time at which release begins	-0.15	-0.18	-0.15

Note: For identifying parameters that impact the peak all pathway dose, a cut-off value of 0.05 was subjectively selected for the SRRC.

Table B-56 Summary of Regression Analysis to Identify Parameters Influencing the Peak Total Dose for the Offsite Resident via Water Transport Scenario (cont.)

Sr-90 Regression Coefficients for Peak All Pathways Dose (cont.)			
Deposition velocity of all particulates (to compute atmospheric release)	0.16	0.17	0.14
Runoff coefficient of catchment area	-0.1	-0.11	-0.12
Soil erodibility factor of cover	0.09	0.11	0.09
Dry bulk density of cover	-0.04	-0.07	-0.06
Deposition velocity of all particulates of Sr	0.05	0.06	0.06
Soil to plant transfer factor of Sr for fruit, grain, nonleafy vegetables	0.06	0.05	0.03
Fraction of eroded radionuclides deposited in the surface water body	0.04	0.05	0.03
Mass loading of all particulates	0.05	0.02	0.04
Tc-99 Regression Coefficients for Peak All Pathways Dose			
Repetition =	1	2	3
Coefficient of determination (R-squared) =	0.71	0.71	0.7
Description of probabilistic Variable	SRRC	SRRC	SRRC
Hydraulic conductivity of saturated zone	0.61	0.61	0.58
Hydraulic gradient of saturated zone to well	0.44	0.43	0.47
K_d of Tc-99 in saturated zone	-0.23	-0.24	-0.22
Cover and management factor in area of primary contamination	0.09	0.1	0.11
K_d of Tc-99 in unsaturated zone	-0.1	-0.09	-0.07
Slope-length-steepness factor in area of primary contamination	0.08	0.09	0.07
Thickness (meters) of unsaturated zone	-0.08	-0.07	-0.08
Distance in the direction parallel to aquifer flow from downgradient edge of contamination	-0.08	-0.07	-0.07
Effective porosity of saturated zone	-0.06	-0.05	-0.07
Rainfall and runoff factor in area of primary contamination	0.07	0.04	0.06
Longitudinal dispersivity of saturated zone to well	0.05	0.06	0.04
Thickness of contaminated zone	0.04	0.06	0.05
Depth of soil mixing layer in area of primary contamination	0.03	0.05	0.04
Soil to plant transfer factor of Tc for fruit, grain, nonleafy vegetables	0.04	0.05	0.03
U-238 Regression Coefficients for Peak All Pathways Dose			
Repetition =	1	2	3
Coefficient of determination (R-squared) =	0.73	0.73	0.72
Description of probabilistic variable	SRRC	SRRC	SRRC
Cover and management factor in area of primary contamination	0.51	0.49	0.49
Slope-length-steepness factor in area of primary contamination	0.42	0.42	0.42
Note: For identifying parameters that impact the peak all pathway dose, a cut-off value of 0.05 was subjectively selected for the SRRC.			

Table B-56 Summary of Regression Analysis to Identify Parameters Influencing the Peak Total Dose for the Offsite Resident via Water Transport Scenario (cont.)

U-238 Regression Coefficients for Peak All Pathways Dose (cont.)			
Depth of soil mixing layer in area of primary contamination	0.28	0.28	0.29
Rainfall and runoff factor in area of primary contamination	0.22	0.26	0.26
Thickness of cover	-0.23	-0.2	-0.21
Deposition velocity of all particulates (to compute atmospheric release)	0.14	0.16	0.14
Intake to animal product transfer factor of U for Meat	0.13	0.15	0.12
Runoff coefficient of catchment area	-0.08	-0.11	-0.11
Soil erodibility factor of cover	0.1	0.09	0.09
Irrigation applied per year (meters/year) to pasture and silage fields	0.06	0.06	0.04
K_d of U-238 in unsaturated zone	-0.04	-0.05	-0.05
Slope-length-steepness factor of catchment area	-0.04	-0.05	-0.04
Dry bulk density of cover	-0.01	-0.05	-0.07
Fraction of eroded radionuclides deposited in the surface water body	0.04	0.04	0.05
Deposition velocity of all particulates of U	0.07	0.04	0.03
Dry bulk density of contaminated zone	0.04	0.03	0.05
Note: For identifying parameters that impact the peak all pathway dose, a cut-off value of 0.05 was subjectively selected for the SRRC.			

B.4 Offsite Resident via Air Transport Scenario

The purpose of this analysis was to illustrate the use of the probabilistic RESRAD-OFFSITE code to simulate the offsite resident via air transport scenario as described in Section 5.4. The probabilistic analysis was performed to identify parameters that have significant effect on peak total dose. In a probabilistic analysis, behavioral parameters were kept at a fixed value and physical parameters were assigned distributions. Only parameters associated with parent radionuclides were assigned distributions. Table˚B-57 lists the input parameters of the RESRAD-OFFSITE code, their base value used in the deterministic calculations, and their statistical distribution (including the distribution function and the associated distribution parameters) used in the probabilistic calculations. Radionuclide or element specific input parameters are listed in separate tables. Tables B-3 through Table B-8 list point values and statistical distributions for the plant transfer factor, meat transfer factor, milk transfer factor, fish bioaccumulation factor, crustacean bioaccumulation factor, and K_d, respectively.

For each probabilistic analysis, input data sets were generated with the specifications of 2,000 observations, three repetitions, and the Latin Hypercube Sampling (LHS) technique. After the probabilistic calculations were completed, the dose results obtained with all input data sets were analyzed by the RESRAD-OFFSITE code, and the average, minimum, maximum, and percentiles of the peak total dose and the peak pathway dose were reported. Tables B-58 through B-69 list the reported results for the offsite resident via air transport scenario for each of the 12 radionuclides selected for evaluation. In the probabilistic analysis, there is a distribution of peak total dose and distribution of peak pathway doses from different simulations. The peak pathway dose may or may not occur at the same time as the peak total dose. To analyze the results two variability criteria were used: ratio of peak dose at 95 to 50 percentile and difference of peak dose at 95 percent to peak dose at 50 percent.

The dominant exposure pathways in this analysis were identified by comparing the peak pathway dose at two percentiles (50 and 95 percentile) to the peak total dose at the same percentiles. The same criteria as used in offsite resident via water transport scenario for identifying dominant exposure pathways was also used in this scenario. Because of the differences in the ratio of peak pathway dose at 95 to 50 percentile in exposure pathway, the dominant exposure pathways at 50 percentile may be different than the dominant exposure pathways at 95 percentile. The dominant exposure pathways at 50 and 95 percentiles are highlighted in Tables B-58 through B-.69. Table B-70 lists dominant exposure pathways for the 50 and 95 dose percentiles.

RESRAD-OFFSITE has two aids to help identify the significant inputs: a regression report with the inputs sorted in descending order of significance and scatter plots of output against inputs. The regression analysis was performed on both raw and ranked data. The code compared the coefficients of determination for the regression on the raw data and the regression on the ranked data. The coefficient of determination measured how well a regression modeled the variation in the output (peak predicted dose). The absolute values of the standardized regression coefficients of the regression, raw or ranked, that had the higher coefficient of determination were used to sort the inputs in descending order of influence.

For identifying parameters that impact the peak total dose, a cut-off value of 0.05 was subjectively selected for the SRRC, judging by the range of SRRC from all input parameters. The selection of a low cut-off value will allow more input parameters to be identified that influence the peak total dose. Table B-71 summarizes the regression analysis results for the air transport scenario. The influence of a parameter is categorized subjectively into three groups: SRRC >0.2 (high influence on dose), SRRC in the range ≥0.1 to 0.2 (medium influence on dose), and SRRC in the range ≥0.05 to <0.1 (low influence on dose). The SRRC cutoff value and its range for categorizing input parameters are not absolute; they depend on the regression analysis results of each run, and should be judged by the analyst. The cutoff value can be verified by another run as described in Section 4.3 and attachment C.4.4 of NUREG/CR-7127 (Yu et al. 2013).

The parameters for each radionuclide as listed in Table B-71 match the dominant exposure pathways identified in Table B-70. These parameters are used in modeling the radiation dose associated with the dominant exposure pathways, thereby influencing the total dose.

Table B-57 Base Values and Statistical Distributions of Input Parameters Used in the RESRAD-OFFSITE Code for Offsite Resident via Air Transport Scenario Analysis

Input screen title/parameter	Units	Type[b]	Base value for deterministic calculation	Source	Probabilistic analysis[a]					Description
					Distribution	Parameter 1	Parameter 2	Parameter 3	Parameter 4	
Title and Radiological Data										
Title	—[c]	NA[d]	RESRAD-OFFSITE Air Transport Scenario	Scenario specific	None	NR	NR	NR	NR	The Title is used to identify the run and can be up to 80 alphabetic or numeri characters long.
Location of dose, slope, and transfer factor database	—	NA	C:\RESRAD_FAMILY\DCF\3.1	Code default	None	NR	NR	NR	NR	The location of the dose factor library contains all dose coefficients, slope factors, and transfer factors for the RESRAD-OFFSITE pathways.
Radionuclide transformation based on	—	NA	ICRP 107	Code default	None	NR	NR	NR	NR	The code has option to select ICRP 107 or ICRP 38 radionuclide transformation database.
External exposure library	—	NA	DCFPAK 3.02	Code default	None	NR	NR	NR	NR	External exposure factor library used.
Internal exposure dose library	—	NA	DOE STD-1196-2011 (reference person)	Code default	None	NR	NR	NR	NR	Internal exposure factor library used.
Slope factor (risk) library	—	NA	DCFPAK 3.02 Morbidity	Code default	None	NR	NR	NR	NR	Slope factor (risk) library used.
Transfer factor library	—	NA	RESRAD default transfer factor	Code default	None	NR	NR	NR	NR	Transfer factor library used.
Cutoff half-life	days	NA	30	Code default	None	NR	NR	NR	NR	The cutoff half-life used to separate the "principal nuclides" from the "associated nuclides."
Number of points	—	NA	1024, 4096	Selected value	None	NR	NR	NR	NR	This parameter specifies the number of graphic points. It affects the precision of the computed results and the smoothness of the output graphic curves. To accurately model the rapidly changing evasion losses for C-14, the number of points used were 4096. For other radionuclides the number of points used were 1024.
Linear spacing/log spacing	—	NA	Linear spacing	Selected value	None	NR	NR	NR	NR	LINEAR or LOG is to specify the type of spacing (years) between the generated time points.
Minimum time increment between points	year	NA	1	Code default	None	NR	NR	NR	NR	Only applicable when log spacing is selected. This is the lowest time interval allowed between two intermediate time points. It is also used to determine the secondary intermediate time point.
Update progress of computation message every	seconds	NA	0.0	Code default	None	NR	NR	NR	NR	An interface parameter that specifies how frequently the progress of computation is to be reported and displayed on the screen.

[a] For truncated lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution, parameter 3 = lower quantile, and parameter 4 = upper quantile; for lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution; for triangular distribution, parameter 1 = minimum, parameter 2 = mode or most likely, and parameter 3 = maximum; for truncated normal distribution, parameter 1 = mean, parameter 2 = standard deviation, parameter 3 = lower quantile, and parameter 4 = upper quantile; for bounded lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution, parameter 3 = minimum value, and parameter 4 = maximum value; for uniform distribution, parameter 1 = minimum, and parameter 2 = maximum; for continuous linear distribution, number of points, value of points, and CDF of points; for continuous logarithmic distribution, number of points, value of points, and CDF of points.

[b] P = physical, B= behavioral, and M = metabolic parameter.

[c] NR = not required.

Table B-57 Base Values and Statistical Distributions of Input Parameters Used in the RESRAD-OFFSITE Code for Offsite Resident via Air Transport Scenario Analysis (cont.)

Input screen title/parameter	Units	Type[b]	Base value for deterministic calculation	Source	Probabilistic analysis[a]					Description
					Distribution	Parameter 1	Parameter 2	Parameter 3	Parameter 4	
Title and Radiological Data (cont.)										
Save input file when a form is saved	—	NA	Not checked	Code default	None	NR	NR	NR	NR	Clicking on this check box saves input file when a form is saved.
Use line draw character	—	NA	Checked	Code default	None	NR	NR	NR	NR	Use line-draw character set in the report files.
Preliminary Inputs										
Radiological units for activity	—	NA	pCi	Code default	None	NR	NR	NR	NR	Any of the four units of radioactivity: Curie (Ci), Becquerel (Bq), disintegrations per second (dps), or disintegrations per minute (dpm) can be selected. Any standard 1-character metric prefix can be used with Ci and Bq.
Radiological units for dose	—	NA	mrem	Code default	None	NR	NR	NR	NR	Both conventional and SI units may be selected for radiation dose.
Basic radiation dose limit	mrem/ yr	NA	25	Code default	None	NR	NR	NR	NR	The annual radiation dose limit in mrem/yr used to derive all site-specific guidelines.
Exposure duration (for risk)	yr	NA	30	Code default	None	NR	NR	NR	NR	The exposure duration is the span of time in years an individual spends at the exposure location for risk calculations.
Number of unsaturated zone	—	P	1	Code default	None	NR	NR3333	NR	NR	Number of unsaturated zones. An unsaturated zone is a horizontal uncontaminated layer located between the contaminated zone and the aquifer.
Submerged fraction of primary contamination	—	P	0	Code default	None	NR	NR	NR	NR	Value greater than 0 indicates that part or all of primary contamination is below the water table.
Conceptualization of primary contamination	—	P	Specify initial activity based on mass of entire primary contamination	Scenario assumption	None	NR	NR	NR	NR	The choice for conceptualization of primary contamination.
Default release mechanism	—	P	Instantaneous equilibrium desorption release	Scenario assumption	None	NR	NR	NR	NR	The default release mechanism selected for the source.
Maximum number of iterations for solubility release	—	NA	5	Code default	None	NR	NR	NR	NR	Not used for First order rate-controlled release.

[a] For truncated lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution, parameter 3 = lower quantile, and parameter 4 = upper quantile; for lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution; for triangular distribution, parameter 1 = minimum, parameter 2 = mode or most likely, and parameter 3 = maximum; for truncated normal distribution, parameter 1 = mean, parameter 2 = standard deviation, parameter 3 = lower quantile, and parameter 4 = upper quantile; for bounded lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution, parameter 3 = minimum value, and parameter 4 = maximum value; for uniform distribution, parameter 1 = minimum, and parameter 2 = maximum; for continuous linear distribution, number of points, value of points, and CDF of points; for continuous logarithmic distribution, number of points, value of points, and CDF of points.

[b] P = physical, B= behavioral, and M = metabolic parameter.

[c] NR = not required.

Table B-57 Base Values and Statistical Distributions of Input Parameters Used in the RESRAD-OFFSITE Code for Offsite Resident via Air Transport Scenario Analysis (cont.)

Input screen title/parameter	Units	Type[b]	Base value for deterministic calculation	Source	Probabilistic analysis[a]					Description
					Distribution	Parameter 1	Parameter 2	Parameter 3	Parameter 4	
Times at which release properties change										
First time at which the GW release begins	yr	P	100	Scenario assumption	None	NR	NR	NR	NR	First time at which release begins.
Number of times at which the release properties change	—	P	1	Assumption	None	NR	NR	NR	NR	This is the number of times release properties change. The code allows a maximum of nine times. Carried to Source Release form.
Source										
Nuclide concentration	pCi/g	P	1	Assumption	None	NR	NR	NR	NR	The radionuclide concentration in the contaminated zone. The contaminated zone is a uniformly contaminated area with a single radionuclide concentration at every point.
Source Release To be input for all nuclides										
Release to groundwater										
Release mechanism	—	P	Instantaneous equilibrium desorption release	Assumption	None	NR	NR	NR	NR	Release mechanisms available depend on the selection in the Preliminary Input form.
Times at which release begins or changes	yr	P	100	Assumption						Parameter is carried from the Times at Which Release Properties change form.
Cumulative fraction of radionuclide-bearing material releasable at different times	—	P	1	Assumption	None	NR	NR	NR	NR	The code conceptualizes two forms of nuclide-bearing material: a release susceptible form and a release immune form. The nuclide-bearing material is protected by engineering barriers and containers can initially be in the release immune form for a period of time. Thereafter, some or all of the nuclide bearing material can change to the release susceptible form as the engineered barriers and containers deteriorate over time. To be input for all radionuclides.

[a] For truncated lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution, parameter 3 = lower quantile, and parameter 4 = upper quantile; for lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution; for triangular distribution, parameter 1 = minimum, parameter 2 = mode or most likely, and parameter 3 = maximum; for truncated normal distribution, parameter 1 = mean, parameter 2 = standard deviation, parameter 3 = lower quantile, and parameter 4 = upper quantile; for bounded lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution, parameter 3 = minimum value, and parameter 4 = maximum value; for uniform distribution, parameter 1 = minimum, and parameter 2 = maximum; for continuous linear distribution, number of points, value of points, and CDF of points; for continuous logarithmic distribution, number of points, value of points, and CDF of points.

[b] P = physical, B= behavioral, and M = metabolic parameter.

[c] NR = not required.

Table B-57 Base Values and Statistical Distributions of Input Parameters Used in the RESRAD-OFFSITE Code for Offsite Resident via Air Transport Scenario Analysis (cont.)

Input screen title/parameter	Units	Type[b]	Base value for deterministic calculation	Source	Probabilistic analysis[a]					Description
					Distribution	Parameter 1	Parameter 2	Parameter 3	Parameter 4	
Release to groundwater (cont.)										
Incremental fraction of radionuclide-bearing material becomes releasable at different times	—	P	Stepwise at time	Assumption	None	NR	NR	NR	NR	Two release options linearly overtime and stepwise in time are available. If linearly over time option is chosen, the releasable fraction is modeled as varying linearly from the initial value to the final value over the time over which the release immune phase transforms to the release susceptible phase. If step wise is chosen, the nuclides in the initial releasable fraction is modeled as being released at the initial leach rate while the nuclides in the nuclide-bearing material that became releasable later are released at the final leach rate. For this scenario it is assumed for the first time, the release is stepwise at time and for the second time release is linearly over time.
Distribution coefficient in primary contamination	cm^3/g	P	See Table B-8	The selected values are from Table 2.13.9 in Data Collection Handbook (Yu et al. 2015). The base values are the values for the generic soil type. The distributions are for the generic soil type.	for all truncated lognormal-n	Table B-8	Table B-8	Table B-8	Table B-8	Site-specific values should be used everywhere for each radionuclide. Default values and distributions are provided by the code for most radionuclides. However, these values should be used with care because distribution coefficients can vary over many orders of magnitude.
Release from surface layer										
Radionuclide becomes available for release	—	P	Beginning at time zero	Assumption	None	NR	NR	NR	NR	Two options, in the same manner as for release to groundwater and beginning at time zero, are available.
Distribution Coefficients To be input for all nuclides										
Contaminated medium	cm^3/g	P	NR	NR	NR	NR	NR	NR	NR	Distribution coefficient for contaminated medium not required in this scenario.

[a] For truncated lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution, parameter 3 = lower quantile, and parameter 4 = upper quantile; for lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution; for triangular distribution, parameter 1 = minimum, parameter 2 = mode or most likely, and parameter 3 = maximum; for truncated normal distribution, parameter 1 = mean, parameter 2 = standard deviation, parameter 3 = lower quantile, and parameter 4 = upper quantile; for bounded lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution, parameter 3 = minimum value, and parameter 4 = maximum value; for uniform distribution, parameter 1 = minimum, and parameter 2 = maximum; for continuous linear distribution, number of points, value of points, and CDF of points; for continuous logarithmic distribution, number of points, value of points, and CDF of points.

[b] P = physical, B= behavioral, and M = metabolic parameter.

[c] NR = not required.

Table B-57 Base Values and Statistical Distributions of Input Parameters Used in the RESRAD-OFFSITE Code for Offsite Resident via Air Transport Scenario Analysis (cont.)

Input screen title/parameter	Units	Type[b]	Base value for deterministic calculation	Source	Probabilistic analysis[a]					Description
					Distribution	Parameter 1	Parameter 2	Parameter 3	Parameter 4	
Distribution Coefficients (cont.) To be input for all nuclides										
Contaminated zone	cm^3/g	P	See Table B-8	The selected values are from Table 2.13.9 in Data Collection Handbook (Yu et al. 2015). The base values are the values for the generic soil type. The distributions are for the generic soil type.	for all truncated lognormal-n	Table B-8	Table B-8	Table B-8	Table B-8	Site-specific values should be used everywhere for each radionuclide. Default values and distributions are provided by the code for most radionuclides. However, these values should be used with care because distribution coefficients can vary over many orders of magnitude.
Unsaturated zone	cm^3/g	P	See Table B-8	Same as above	Same as above	Same as above	Same as above	Same as above	Same as above	Same as above
Saturated zone	cm^3/g	P	See Table B-8	Same as above	Same as above	Same as above	Same as above	Same as above	Same as above	Same as above
Suspended sediment in surface water body	cm^3/g	P	See Table B-8	Same as above	Same as above	Same as above	Same as above	Same as above	Same as above	Same as above
Bottom sediment in surface water body	cm^3/g	P	See Table B-8	Same as above	Same as above	Same as above	Same as above	Same as above	Same as above	Same as above
Fruit, grain, non-leafy fields	cm^3/g	P	See Table B-8	For deterministic run, base values are from Table 2.13.9 in Data Collection Handbook (Yu et al. 2015).	None	NR	NR	NR	NR	Same as above
Leafy vegetable fields	cm^3/g	P	See Table B-8	Same as above	None	NR	NR	NR	NR	Same as above
Pasture, silage growing areas	cm^3/g	P	See Table B-8	Same as above	None	NR	NR	NR	NR	Same as above
Livestock feed grain fields	cm^3/g	P	See Table B-8	Same as above	None	NR	NR	NR	NR	Same as above
Dwelling site	cm^3/g	P	See Table B-8	Same as above	None	NR	NR	NR	NR	Same as above

[a] For truncated lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution, parameter 3 = lower quantile, and parameter 4 = upper quantile; for lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution; for triangular distribution, parameter 1 = minimum, parameter 2 = mode or most likely, and parameter 3 = maximum; for truncated normal distribution, parameter 1 = mean, parameter 2 = standard deviation, parameter 3 = lower quantile, and parameter 4 = upper quantile; for bounded lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution, parameter 3 = minimum value, and parameter 4 = maximum value; for uniform distribution, parameter 1 = minimum, and parameter 2 = maximum; for continuous linear distribution, number of points, value of points, and CDF of points; for continuous logarithmic distribution, number of points, value of points, and CDF of points.

[b] P = physical, B= behavioral, and M = metabolic parameter.

[c] NR = not required.

Table B-57 Base Values and Statistical Distributions of Input Parameters Used in the RESRAD-OFFSITE Code for Offsite Resident via Air Transport Scenario Analysis (cont.)

Input screen title/parameter	Units	Type[b]	Base value for deterministic calculation	Source	Probabilistic analysis[a]					Description
					Distribution	Parameter 1	Parameter 2	Parameter 3	Parameter 4	
Deposition Velocities To be input for all nuclides										
Deposition velocity of respirable particulates	m/s	P	0.001*	For deterministic run base value is the code default and for probabilistic run distribution from Yu et. al. 2007 is used.	Log uniform	1E-6	1	NR	NR	The representative deposition velocity of respirable airborne particulates with which the nuclide shown in the form is associated. This is used to model the settling of respirable particulates in the dust plume during atmospheric transport. Some radionuclides are also released from the primary contamination in the form of a gas, (water vapor, carbon dioxide, radon, etc.) and are transported as a gas. The code models the transport of gases separately from the transport of the particulates and uses a deposition velocity of zero when modeling transport of gases. The value entered here is not used in modeling the transport of gases.
Deposition velocity of all particulates	m/s	P	0.001*	For deterministic run base value is the code default and for probabilistic run distribution from Yu et. al. 2007 is used.	Log uniform	1E-6	1	NR	NR	The representative deposition velocity of all the airborne particulates with which the nuclide shown in the form is associated with. This is used to model the settling of all the particulates in the dust plume during atmospheric transport. Some radionuclides are also released from the primary contamination in the form of a gas, (water vapor, carbon dioxide, radon, etc.) and are transported as a gas. The code models the transport of gases separately from the transport of the particulates and uses a deposition velocity of zero when modeling transport of gases. The value entered here is not used in modeling the transport of gases.

[a] For truncated lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution, parameter 3 = lower quantile, and parameter 4 = upper quantile; for lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution; for triangular distribution, parameter 1 = minimum, parameter 2 = mode or most likely, and parameter 3 = maximum; for truncated normal distribution, parameter 1 = mean, parameter 2 = standard deviation, parameter 3 = lower quantile, and parameter 4 = upper quantile; for bounded lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution, parameter 3 = minimum value, and parameter 4 = maximum value; for uniform distribution, parameter 1 = minimum, and parameter 2 = maximum; for continuous linear distribution, number of points, value of points, and CDF of points; for continuous logarithmic distribution, number of points, value of points, and CDF of points.

[b] P = physical, B= behavioral, and M = metabolic parameter.

[c] NR = not required.

Table B-57 Base Values and Statistical Distributions of Input Parameters Used in the RESRAD-OFFSITE Code for Offsite Resident via Air Transport Scenario Analysis (cont.)

Input screen title/parameter	Units	Type[b]	Base value for deterministic calculation	Source	Probabilistic analysis[a]					Description
					Distribution	Parameter 1	Parameter 2	Parameter 3	Parameter 4	
Transfer Factors To be input for all nuclides										
Plant transfer factor for fruit, grain, non-leafy vegetables	(pCi/kg)/(pCi/kg)	P	See Table B-3	For deterministic run, median value from the parameter distribution is used as a base value. For probabilistic run, distributions from Yu et al. 2015 are used.	for all truncated lognormal-n	Table B-3	Table B-3	Table B-3	Table B-3	The ratio of radionuclide concentration in edible portions of the plant at harvest time to the dry soil radionuclide concentration. Assumed that the same plant transfer factors can be used for leafy and non-leafy vegetables. The code has element specific values and the user is allowed to change these values.
Plant transfer factor for leafy vegetables	(pCi/kg)/(pCi/kg)	P	See Table B-3	Same as above	Same as above	Same as above	Same as above	Same as above	Same as above	Same as above
Plant transfer factor for pasture and silage	(pCi/kg)/(pCi/kg)	P	See Table B-3	Same as above	Same as above	Same as above	Same as above	Same as above	Same as above	Same as above
Plant transfer factor for livestock feed grain	(pCi/kg)/(pCi/kg)	P	See Table B-3	Same as above	Same as above	Same as above	Same as above	Same as above	Same as above	Same as above
Meat transfer factor	(pCi/kg)/(pCi/d)	P	See Table B-4	Same as above	for all truncated lognormal-n	Table B-4	Table B-4	Table B-4	Table B-4	The ratio of radionuclide concentration in beef to the daily intake of the same radionuclide in livestock feed or water. The code has element specific values and the user is allowed to change these values.
Milk transfer factor	(pCi/L)/(pCi/d)	P	See Table B-5	Same as above	for all truncated lognormal-n	Table B-5	Table B-5	Table B-5	Table B-5	The ratio of radionuclide concentration in milk to the daily intake of the same radionuclide in the livestock feed or water. The code has element specific values and the user is allowed to change these values.
Fish bioaccumulation factor	(pCi/kg)/(pCi/L)	P	See Table B-6	Same as above	for all lognormal-n	Table B-6	Table B-6	Table B-6	Table B-6	The ratio of radionuclide concentration in the aquatic food to the concentration of the same radionuclide in water. The code has element specific aquatic bioaccumulation factors for fish and crustacea and mollusks and the user is allowed to change these values.

[a] For truncated lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution, parameter 3 = lower quantile, and parameter 4 = upper quantile; for lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution; for triangular distribution, parameter 1 = minimum, parameter 2 = mode or most likely, and parameter 3 = maximum; for truncated normal distribution, parameter 1 = mean, parameter 2 = standard deviation, parameter 3 = lower quantile, and parameter 4 = upper quantile; for bounded lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution, parameter 3 = minimum value, and parameter 4 = maximum value; for uniform distribution, parameter 1 = minimum, and parameter 2 = maximum; for continuous linear distribution, number of points, value of points, and CDF of points; for continuous logarithmic distribution, number of points, value of points, and CDF of points.

[b] P = physical, B= behavioral, and M = metabolic parameter.

[c] NR = not required.

Table B-57 Base Values and Statistical Distributions of Input Parameters Used in the RESRAD-OFFSITE Code for Offsite Resident via Air Transport Scenario Analysis (cont.)

Input screen title/parameter	Units	Type[b]	Base value for deterministic calculation	Source	Probabilistic analysis[a]					Description
					Distribution	Parameter 1	Parameter 2	Parameter 3	Parameter 4	
Transfer Factors (cont.) To be input for all nuclides										
Crustacea bioaccumulation factor	(pCi/kg)/ (pCi/L)	P	See Table B-7	For deterministic run, base values from Yu et al, 2015 are used.	None	NR	NR	NR	NR	The ratio of radionuclide concentration in the aquatic food to the concentration of the same radionuclide in water. The code has element specific aquatic bioaccumulation factors for fish and crustacea and mollusks and the user is allowed to change these values.
Reporting Times										
Times at which output is reported	yr	P	1, 3, 10, 30, 100, 300, 1000	Selected values	None	NR	NR	NR	NR	These are the times in years following the radiological survey for which tabular values for single-radionuclide soil guidelines and mixture sums are obtained. The code produces text reports at time zero and up to nine user-specified times. The times selected depend on the radionuclide analyzed. For short-lived radionuclides less reporting times are used.
Storage Times The storage times used to calculate radioactive ingrowth and decay adjustment factors for food and feed due to storage. The code has values for fruits, non-leafy vegetables, and grain (one category), leafy vegetables, pasture and silage, milk, well and surface water, livestock feed grain, meat, fish, and crustacea and mollusks.										
Storage time for surface water	d	B	1	Code default	None	NR	NR	NR	NR	
Storage time for well water	d	B	1	Code default	None	NR	NR	NR	NR	
Storage time for fruits, grain, and non-leafy vegetables	d	B	14	Code default	None	NR	NR	NR	NR	
Storage time for leafy vegetables	d	B	1	Code default	None	NR	NR	NR	NR	
Storage time for pasture and silage	d	B	1	Code default	None	NR	NR	NR	NR	
Storage time for livestock feed grain	d	B	45	Code default	None	NR	NR	NR	NR	
Storage time for meat	d	B	20	Code default	None	NR	NR	NR	NR	
Storage time for milk	d	B	1	Code default	None	NR	NR	NR	NR	

[a] For truncated lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution, parameter 3 = lower quantile, and parameter 4 = upper quantile; for lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution; for triangular distribution, parameter 1 = minimum, parameter 2 = mode or most likely, and parameter 3 = maximum; for truncated normal distribution, parameter 1 = mean, parameter 2 = standard deviation, parameter 3 = lower quantile, and parameter 4 = upper quantile; for bounded lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution, parameter 3 = minimum value, and parameter 4 = maximum value; for uniform distribution, parameter 1 = minimum, and parameter 2 = maximum; for continuous linear distribution, number of points, value of points, and CDF of points; for continuous logarithmic distribution, number of points, value of points, and CDF of points.

[b] P = physical, B= behavioral, and M = metabolic parameter.

[c] NR = not required.

Table B-57 Base Values and Statistical Distributions of Input Parameters Used in the RESRAD-OFFSITE Code for Offsite Resident via Air Transport Scenario Analysis (cont.)

Input screen title/parameter	Units	Type[b]	Base value for deterministic calculation	Source	Probabilistic analysis[a]					Description
					Distribution	Parameter 1	Parameter 2	Parameter 3	Parameter 4	
Storage Times (cont.) The storage times used to calculate radioactive ingrowth and decay adjustment factors for food and feed due to storage. The code has values for fruits, non-leafy vegetables, and grain (one category), leafy vegetables, pasture and silage, milk, well and surface water, livestock feed grain, meat, fish, and crustacea and mollusks.										
Storage time for fish	d	B	7	Code default	None	NR	NR	NR	NR	
Storage time for crustacea and mollusks	d	B	7	Code default	None	NR	NR	NR	NR	
Site Layout										
Bearing of X-axis (clockwise angle from North)	degree	P	90	Site specific	None	NR	NR	NR	NR	
X-dimension of primary contamination	m	P	100	Site specific	None	NR	NR	NR	NR	The primary contamination modeled as a rectangle for atmospheric transport calculations. The lengths of the sides on the rectangle, the X and Y dimension, were used to define rectangular region for atmospheric transport calculations.
Y-dimension of primary contamination	m	P	100	Site specific	None	NR	NR	NR	NR	
Smaller X-coordinate of the fruit, grain, nonleafy vegetables plot	m	P	34.375	Site specific	None	NR	NR	NR	NR	The fruit, grain, and non-leafy vegetables, the leafy vegetables, the pasture and silage, the livestock-feed grain growing areas and dwelling site were all approximated by rectangular shapes. The sides of these rectangles must be parallel to the sides of the primary contamination. The location and size of these rectangles were specified by the Cartesian coordinates of two opposite corners.
Larger X-coordinate of the fruit, grain, nonleafy vegetables plot	m	P	65.625	Site specific	None	NR	NR	NR	NR	See above
Smaller Y-coordinate of the fruit, grain, nonleafy vegetables plot	m	P	234	Site specific	None	NR	NR	NR	NR	See above
Larger Y-coordinate of the fruit, grain, nonleafy vegetables plot	m	P	266	Site specific	None	NR	NR	NR	NR	See above
Smaller X-coordinate of the leafy vegetables plot	m	P	34.375	Site specific	None	NR	NR	NR	NR	See above

[a] For truncated lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution, parameter 3 = lower quantile, and parameter 4 = upper quantile; for lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution; for triangular distribution, parameter 1 = minimum, parameter 2 = mode or most likely, and parameter 3 = maximum; for truncated normal distribution, parameter 1 = mean, parameter 2 = standard deviation, parameter 3 = lower quantile, and parameter 4 = upper quantile; for bounded lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution, parameter 3 = minimum value, and parameter 4 = maximum value; for uniform distribution, parameter 1 = minimum, and parameter 2 = maximum; for continuous linear distribution, number of points, value of points, and CDF of points; for continuous logarithmic distribution, number of points, value of points, and CDF of points.

[b] P = physical, B= behavioral, and M = metabolic parameter.

[c] NR = not required.

Table B-57 Base Values and Statistical Distributions of Input Parameters Used in the RESRAD-OFFSITE Code for Offsite Resident via Air Transport Scenario Analysis (cont.)

Input screen title/parameter	Units	Type[b]	Base value for deterministic calculation	Source	Probabilistic analysis[a]					Description
					Distribution	Parameter 1	Parameter 2	Parameter 3	Parameter 4	
Site Layout (cont.)										
Larger X-coordinate of the leafy vegetables plot	m	P	65.625	Site specific	None	NR	NR	NR	NR	See above
Smaller Y-coordinate of the leafy vegetables plot	m	P	268	Site specific	None	NR	NR	NR	NR	See above
Larger Y-coordinate of the leafy vegetables plot	m	P	300	Site specific	None	NR	NR	NR	NR	See above
Smaller X coordinate of the pasture, silage growing area	m	P	0	Site specific	None	NR	NR	NR	NR	See above
Larger X-coordinate of the pasture, silage growing area	m	P	100	Site specific	None	NR	NR	NR	NR	See above
Smaller Y-coordinate of the pasture, silage growing area	m	P	450	Site specific	None	NR	NR	NR	NR	See above
Larger Y-coordinate of the pasture, silage growing area	m	P	550	Site specific	None	NR	NR	NR	NR	See above
Smaller X-coordinate of the grain fields	m	P	0	Site specific	None	NR	NR	NR	NR	See above
Larger X-coordinate of the grain fields	m	P	100	Site specific	None	NR	NR	NR	NR	See above
Smaller Y-coordinate of the grain fields	m	P	300	Site specific	None	NR	NR	NR	NR	See above
Larger Y-coordinate of the grain fields	m	P	400	Site specific	None	NR	NR	NR	NR	See above
Smaller-X coordinate of the dwelling site	m	P	34.375	Site specific	None	NR	NR	NR	NR	See above
Larger X coordinate of the dwelling site	m	P	65/625	Site specific	None	NR	NR	NR	NR	See above
Smaller Y-coordinate of the dwelling site	m	P	134	Site specific	None	NR	NR	NR	NR	See above
Larger Y-coordinate of the dwelling site	m	P	166	Site specific	None	NR	NR	NR	NR	See above

[a] For truncated lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution, parameter 3 = lower quantile, and parameter 4 = upper quantile; for lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution; for triangular distribution, parameter 1 = minimum, parameter 2 = mode or most likely, and parameter 3 = maximum; for truncated normal distribution, parameter 1 = mean, parameter 2 = standard deviation, parameter 3 = lower quantile, and parameter 4 = upper quantile; for bounded lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution, parameter 3 = minimum value, and parameter 4 = maximum value; for uniform distribution, parameter 1 = minimum, and parameter 2 = maximum; for continuous linear distribution, number of points, value of points, and CDF of points; for continuous logarithmic distribution, number of points, value of points, and CDF of points.

[b] P = physical, B= behavioral, and M = metabolic parameter.

[c] NR = not required.

Table B-57 Base Values and Statistical Distributions of Input Parameters Used in the RESRAD-OFFSITE Code for Offsite Resident via Air Transport Scenario Analysis (cont.)

Input screen title/parameter	Units	Type[b]	Base value for deterministic calculation	Source	Probabilistic analysis[a]					Description
					Distribution	Parameter 1	Parameter 2	Parameter 3	Parameter 4	
Site Layout (cont.)										
Smaller X-coordinate of the surface-water body	m	P	-100	Site specific	None	NR	NR	NR	NR	The surface water body approximated by rectangular shape in the atmospheric transport model. The sides of the rectangle are parallel to the sides of primary contamination.
Larger X-coordinate of the surface-water body	m	P	200	Site specific	None	NR	NR	NR	NR	See above
Smaller Y-coordinate of the surface-water body	m	P	550	Site specific	None	NR	NR	NR	NR	See above
Larger Y-coordinate of the surface-water body	m	P	850	Site specific	None	NR	NR	NR	NR	See above
Physical and Hydrological										
Precipitation	m/yr	P	0.5	Code default	None	NR	NR	NR	NR	The average volume of water in the form of rain, snow, hail, or sleet that falls per unit of area per unit of time at the site. It is used in a number of calculations including radionuclide leaching from the contaminated zone, and accumulation of contaminants in the agricultural fields and pastures. Site-specific data should be used.
Wind speed	m/s	P	.89	Code default	None	NR	NR	NR	NR	It is the overall average of the wind speed, measured near the ground, in a one-year period. Used to compute the onsite contaminant concentration in airborne dust and the atmospheric release rate.
Primary Contamination										
Area of primary contamination	m^2	P	10,000	Code default	None	NR	NR	NR	NR	Total area of the site homogeneously contaminated.

[a] For truncated lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution, parameter 3 = lower quantile, and parameter 4 = upper quantile; for lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution; for triangular distribution, parameter 1 = minimum, parameter 2 = mode or most likely, and parameter 3 = maximum; for truncated normal distribution, parameter 1 = mean, parameter 2 = standard deviation, parameter 3 = lower quantile, and parameter 4 = upper quantile; for bounded lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution, parameter 3 = minimum value, and parameter 4 = maximum value; for uniform distribution, parameter 1 = minimum, and parameter 2 = maximum; for continuous linear distribution, number of points, value of points, and CDF of points; for continuous logarithmic distribution, number of points, value of points, and CDF of points.

[b] P = physical, B= behavioral, and M = metabolic parameter.

[c] NR = not required.

Table B-57 Base Values and Statistical Distributions of Input Parameters Used in the RESRAD-OFFSITE Code for Offsite Resident via Air Transport Scenario Analysis (cont.)

Input screen title/parameter	Units	Type[b]	Base value for deterministic calculation	Source	Probabilistic analysis[a]					Description
					Distribution	Parameter 1	Parameter 2	Parameter 3	Parameter 4	
Primary Contamination (cont.)										
Length of contamination parallel to aquifer flow	m	P	100	Code default	None	NR	NR	NR	NR	The distance between two parallel lines perpendicular to the direction of aquifer flow, one at the upgradient edge of the contaminated zone and the other at the downgradient edge of the contaminated zone.
Depth of soil-mixing layer	m	P, B	0.15	For deterministic run, base value selected is the median from the distribution. For probabilistic run, distribution from NUREG/CR-6697 is used.	Triangular	0	0.15	0.6		The thickness of surface soil that may be assumed to be mixed uniformly from time to time due to anthropogenic or physical processes. It is used in calculating the depth factor for the onsite components of dust inhalation, and ingestion pathways, and for computing the release to the atmosphere. The depth factor is the fraction of resuspendable soil particles at the ground surface that are contaminated, which is calculated by assuming that mixing of the soil will occur within a layer of thickness (depth of mixing layer) at the surface.
Mass loading of all particulates	g/m^3	B	0.0001	For deterministic run, base value selected is the code default. For probabilistic run, distribution from Yu et al. 2007 is used.	Truncated lognormal-N	-10.02	0.455	0.001	0.999	This air/soil concentration ratio or the average mass of all particulates in a unit volume of air is above the primary contamination or the offsite location. It is ssed to compute the rate of release of all particulates from the primary contamination or from each of the offsite locations.
Deposition velocity of all particulates	m/s	P	0.001	For deterministic run, base value selected is the code default. For probabilistic run, distribution from Yu et al. 2007 is used.	Log uniform	1E-6	1			The average velocity of all particulates that settles withonto the contaminated zone. Used to calculate the release to the atmosphere. Required for all radionuclides.
Respirable particulates as a fraction of total particulates	—	P	1	Code default	NA	NA	NA	NA	NA	Fraction of respirable particulates.

[a] For truncated lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution, parameter 3 = lower quantile, and parameter 4 = upper quantile; for lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution; for triangular distribution, parameter 1 = minimum, parameter 2 = mode or most likely, and parameter 3 = maximum; for truncated normal distribution, parameter 1 = mean, parameter 2 = standard deviation, parameter 3 = lower quantile, and parameter 4 = upper quantile; for bounded lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution, parameter 3 = minimum value, and parameter 4 = maximum value; for uniform distribution, parameter 1 = minimum, and parameter 2 = maximum; for continuous linear distribution, number of points, value of points, and CDF of points; for continuous logarithmic distribution, number of points, value of points, and CDF of points.

[b] P = physical, B= behavioral, and M = metabolic parameter.

[c] NR = not required.

Table B-57 Base Values and Statistical Distributions of Input Parameters Used in the RESRAD-OFFSITE Code for Offsite Resident via Air Transport Scenario Analysis (cont.)

Input screen title/parameter	Units	Type[b]	Base value for deterministic calculation	Source	Probabilistic analysis[a]					Description
					Distribution	Parameter 1	Parameter 2	Parameter 3	Parameter 4	
Primary Contamination (cont.)										
Deposition velocity of respirable particulates	m/s	P	0.001	For deterministic run, base value selected is the code default. For probabilistic run, distribution from Yu et al. 2007 is used.	Log uniform	1E-6	1			The average velocity of respirable particulates that t settles with dust onto the contaminated zone. It is used to calculate the release to the atmosphere. Required for all radionuclides.
Irrigation applied per year	m/yr	B	0.2	For deterministic run, the base value selected is the code default. For probabilistic run, the minimum being 1/2 of the base value, and the maximum being two times the base value.	Uniform	0.1	0.4			The average annual irrigation rate, in meters/year, applied to the region of primary contamination. It is the amount of irrigation water applied over a period of one year not just that applied during the growing period. It is one of the parameters used to calculate radionuclide leaching from the contaminated zone. Site-specific data should be used.
Evapotranspiration coefficient	—	P	0.5	For deterministic run, base value selected is the code default. For probabilistic run, + /- 50 percent of deterministic value is used.	Uniform	0.25	0.75			The fraction of precipitation and irrigation water that penetrates the topsoil lost to the atmosphere by evaporation and by transpiration by the vegetation. The evapotranspiration coefficient is one of a number of parameters used to calculate radionuclide leaching from the contaminated zone.
Runoff coefficient	—	P	0.2	For deterministic run, base value selected is the code default. For probabilistic run distribution from NUREG/CR-6697	Uniform	0.1	0.8			The fraction of the average annual precipitation that does not penetrate the top soil, but leaves the area of concern as surface runoff. The runoff coefficient is one of a number of parameters used to calculate radionuclide leaching from the contaminated zone.

[a] For truncated lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution, parameter 3 = lower quantile, and parameter 4 = upper quantile; for lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution; for triangular distribution, parameter 1 = minimum, parameter 2 = mode or most likely, and parameter 3 = maximum; for truncated normal distribution, parameter 1 = mean, parameter 2 = standard deviation, parameter 3 = lower quantile, and parameter 4 = upper quantile; for bounded lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution, parameter 3 = minimum value, and parameter 4 = maximum value; for uniform distribution, parameter 1 = minimum, and parameter 2 = maximum; for continuous linear distribution, number of points, value of points, and CDF of points; for continuous logarithmic distribution, number of points, value of points, and CDF of points.

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[c] NR = not required.

Table B-57 Base Values and Statistical Distributions of Input Parameters Used in the RESRAD-OFFSITE Code for Offsite Resident via Air Transport Scenario Analysis (cont.)

Input screen title/parameter	Units	Type[b]	Base value for deterministic calculation	Source	Probabilistic analysis[a]					Description
					Distribution	Parameter 1	Parameter 2	Parameter 3	Parameter 4	
Primary Contamination (cont.)										
Rainfall and runoff factor	—	P	160	For deterministic run, base value selected is the code default. For probabilistic run, distribution from Yu et al. 2007 is used.	Continuous linear					Known as the rainfall erosivity factor, it is a measure of the energy of the rainfall. The value entered is used to compute the erosion rate at all locations.
Slope-length, steepness factor	—	P	.4	For deterministic run, base value selected is the code default. For probabilistic run, distribution from Yu et al. 2007 is used.	Continuous linear					This factor accounts for the effect of the profile of the terrain (the slope of the land and the length of the slope) on the erosion rate.
Cover and management factor	–	B, P	0.003	For deterministic run, base value selected is the code default. For probabilistic run, distribution from Yu et al. 2007 is used.	Continuous linear					This factor accounts for the effects of vegetation, mulching, etc., on the erosion rate.
Support practice factor	—	B, P	1	For deterministic run, base value selected is the code default. For probabilistic run, distribution from Yu et al. 2007 is used.	Continuous linear					This factor accounts for conservation practices aimed at reducing erosion.
Fraction of primary contamination submerged	—	P	0	Site specific – no distribution						Part of the primary contamination below the water table.

[a] For truncated lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution, parameter 3 = lower quantile, and parameter 4 = upper quantile; for lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution; for triangular distribution, parameter 1 = minimum, parameter 2 = mode or most likely, and parameter 3 = maximum; for truncated normal distribution, parameter 1 = mean, parameter 2 = standard deviation, parameter 3 = lower quantile, and parameter 4 = upper quantile; for bounded lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution, parameter 3 = minimum value, and parameter 4 = maximum value; for uniform distribution, parameter 1 = minimum, and parameter 2 = maximum; for continuous linear distribution, number of points, value of points, and CDF of points; for continuous logarithmic distribution, number of points, value of points, and CDF of points.

[b] P = physical, B= behavioral, and M = metabolic parameter.

[c] NR = not required.

Table B-57 Base Values and Statistical Distributions of Input Parameters Used in the RESRAD-OFFSITE Code for Offsite Resident via Air Transport Scenario Analysis (cont.)

Input screen title/parameter	Units	Type[b]	Base value for deterministic calculation	Source	Probabilistic analysis[a]					Description
					Distribution	Parameter 1	Parameter 2	Parameter 3	Parameter 4	
Contaminated zone										
Thickness of contaminated zone above water table	m	P	2	For deterministic run, base value selected is the code default. For probabilistic run, minimum value is 50 percent lower than the base value and maximum value is 50 percent higher than the base value.	Uniform	1	3			The distance between the uppermost and lowermost soil samples with radionuclide concentrations clearly above background.
Total porosity of contaminated zone	—	P	0.425	For deterministic run, base value selected is the mean from the distribution. For probabilistic run, distribution from NUREG/CR-6697 is used.	Truncated normal	0.425	.0867	0.001	0.999	This is the ratio of the pore volume to the total volume of the contaminated zone.
Erosion rate of contaminated zone	—	NA	1.132E-5 (calculated)	Calculated	NA	NA	NA	NA	NA	Calculated
Dry, bulk density of contaminated zone	g/cm^3	P	1.52	For deterministic run, base value selected is the mean from the distribution. For probabilistic run, distribution from NUREG/CR-6697 is used.	Truncated normal	1.52	0.23	0.001	0.999	Bulk density of the contaminated zone.

[a] For truncated lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution, parameter 3 = lower quantile, and parameter 4 = upper quantile; for lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution; for triangular distribution, parameter 1 = minimum, parameter 2 = mode or most likely, and parameter 3 = maximum; for truncated normal distribution, parameter 1 = mean, parameter 2 = standard deviation, parameter 3 = lower quantile, and parameter 4 = upper quantile; for bounded lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution, parameter 3 = minimum value, and parameter 4 = maximum value; for uniform distribution, parameter 1 = minimum, and parameter 2 = maximum; for continuous linear distribution, number of points, value of points, and CDF of points; for continuous logarithmic distribution, number of points, value of points, and CDF of points.

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[c] NR = not required.

Table B-57 Base Values and Statistical Distributions of Input Parameters Used in the RESRAD-OFFSITE Code for Offsite Resident via Air Transport Scenario Analysis (cont.)

Input screen title/parameter	Units	Type[b]	Base value for deterministic calculation	Source	Probabilistic analysis[a]					Description
					Distribution	Parameter 1	Parameter 2	Parameter 3	Parameter 4	
Contaminated zone (cont.)										
Soil erodibility factor of contaminated zone	tons/acre	P	0.4	For deterministic run, base value selected is the code default. For probabilistic run, distribution from Yu et al. 2007 is used.	Continuous linear	None	NR	NR	NR	This quantifies the susceptibility of the soil to erosion.
Effective porosity	—	P	0.355	For deterministic run, base value selected is the mean from the distribution. For probabilistic run, distribution from NUREG/CR-6697 is used.	Truncated normal	0.355	0.0906	0.001	0.999	The volume fraction of soil through which water flows. Part of the soil moisture may not contribute to the movement of contaminants. Thus the effective porosity will be less than or equal to the total porosity.
Field capacity of contaminated zone	—	P	0.3	Code default	None	NR	NR	NR	NR	The volumetric moisture content of soil at which (free) gravity drainage ceases. The amount of moisture retained in a column of soil against the force of gravity. The field capacity is one of several hydrogeological parameters used to calculate water transport through the unsaturated part of the soil.
Soil b parameter of contaminated zone	—	P	5.3	For deterministic run, base value selected is the code default. For probabilistic run, distribution from NUREG/CR-6697 is used.	Bounded lognormal-N	1.06	0.66	0.5	30	This is an empirical and dimensionless parameter used to evaluate the saturation ratio (or the volumetric water saturation) of the soil according to a soil characteristic function called the conductivity function.
Hydraulic conductivity of contaminated zone	m/yr	P	10	For deterministic run, base value selected is the code default.	None	NR	NR	NR	NR	It is the measure of the soil's ability to transmit water when subjected to a hydraulic gradient. The hydraulic conductivity depends on the soil grain size, the structure of the soil matrix, the type of soil fluid, and the relative amount of soil fluid (saturation) present in the soil matrix.

[a] For truncated lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution, parameter 3 = lower quantile, and parameter 4 = upper quantile; for lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution; for triangular distribution, parameter 1 = minimum, parameter 2 = mode or most likely, and parameter 3 = maximum; for truncated normal distribution, parameter 1 = mean, parameter 2 = standard deviation, parameter 3 = lower quantile, and parameter 4 = upper quantile; for bounded lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution, parameter 3 = minimum value, and parameter 4 = maximum value; for uniform distribution, parameter 1 = minimum, and parameter 2 = maximum; for continuous linear distribution, number of points, value of points, and CDF of points; for continuous logarithmic distribution, number of points, value of points, and CDF of points.

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[c] NR = not required.

Table B-57 Base Values and Statistical Distributions of Input Parameters Used in the RESRAD-OFFSITE Code for Offsite Resident via Air Transport Scenario Analysis (cont.)

Input screen title/parameter	Units	Type[b]	Base value for deterministic calculation	Source	Probabilistic analysis[a]					Description
					Distribution	Parameter 1	Parameter 2	Parameter 3	Parameter 4	
Contaminated zone (cont.)										
Longitudinal dispersivity	m	P	0.05	For deterministic run, base value selected is the code default. For probabilistic run uniform between half and double of the default value.	Uniform	0.025	0.1	None	NR	The ratio between the longitudinal dispersion coefficient and pore water velocity.
Depth of top of primary contamination below water table	m	P	0	Code default	None	NR	NR	NR	NR	Calculated
Clean cover										
Thickness of clean cover	m	P	0	Code default	None	NR	NR	NR	NR	Distance from the ground surface to the contaminated zone.
Total porosity of clean cover	—	P	0.4	NR	NR	NR	NR	NR	NR	The volume fraction of soil occupied by liquid and gaseous phases. The total porosity is one of several hydrogeological parameters used to calculate water transport times.
Erosion rate of clean cover	m/yr	NA	1.132E-5 (calculated)							Calculated
Dry bulk density of clean cover	g/cm^3	P	1.5	NR	NR	NR	NR	NR	NR	Bulk density of the cover material
Soil erodibility factor of clean cover	tons/acre	P	0.4	NR	NR	NR	NR	NR	NR	See contaminated zone soil erodibility factor parameter.
Volumetric water content of clean cover	—	P	0.05	NR	NR	NR	NR	NR	NR	It is the volumetric water content in a porous medium that represents the fraction of the total volume of porous medium occupied by the water. The value should be less than the total porosity of the medium.
Fate of Material Eroded from the Primary Contamination by Runoff										
Fraction of eroded radionuclides deposited at dwelling site	—	P	0	Assumption	NR	NR	NR	NR	NR	The fraction of the contaminated soil that eroded from the area of primary contamination that reaches the dwelling site.

[a] For truncated lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution, parameter 3 = lower quantile, and parameter 4 = upper quantile; for lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution; for triangular distribution, parameter 1 = minimum, parameter 2 = mode or most likely, and parameter 3 = maximum; for truncated normal distribution, parameter 1 = mean, parameter 2 = standard deviation, parameter 3 = lower quantile, and parameter 4 = upper quantile; for bounded lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution, parameter 3 = minimum value, and parameter 4 = maximum value; for uniform distribution, parameter 1 = minimum, and parameter 2 = maximum; for continuous linear distribution, number of points, value of points, and CDF of points; for continuous logarithmic distribution, number of points, value of points, and CDF of points.

[b] P = physical, B= behavioral, and M = metabolic parameter.

[c] NR = not required.

Table B-57 Base Values and Statistical Distributions of Input Parameters Used in the RESRAD-OFFSITE Code for Offsite Resident via Air Transport Scenario Analysis (cont.)

Input screen title/parameter	Units	Type[b]	Base value for deterministic calculation	Source	Probabilistic analysis[a]					Description
					Distribution	Parameter 1	Parameter 2	Parameter 3	Parameter 4	
Fate of Material Eroded from the Primary Contamination by Runoff (cont.)										
Fraction of eroded radionuclides deposited in the non-leafy vegetable plot	—	P	0	Assumption	NR	NR	NR	NR	NR	The fraction of the contaminated soil that eroded from the area of primary contamination that reaches the nonleafy vegetable plot.
Fraction of eroded radionuclides deposited in the leafy vegetable plot	—	P	0	Assumption	NR	NR	NR	NR	NR	The fraction of the contaminated soil that eroded from the area of primary contamination that reaches the leafy vegetable plot.
Fraction of eroded radionuclides deposited in the pasture plot	—	P	0	Assumption	NR	NR	NR	NR	NR	The fraction of the contaminated soil that eroded from the area of primary contamination that reaches the pasture plot.
Fraction of eroded radionuclides deposited in the feed grain plot	—	P	0	Assumption	NR	NR	NR	NR	NR	The fraction of the contaminated soil that eroded from the area of primary contamination that reaches the feed grain plot.
Fraction of eroded radionuclides deposited in the surface water body	—	P	1	Assumption	NR	NR	NR	NR	NR	The fraction of the contaminated soil that eroded from the area of primary contamination that reaches the surface water body.
Agricultural Areas										
Fruit, grain, non-leafy vegetables										For description of parameters see description in contaminated zone and cover parameters.
Area of fruit, grain, and non-leafy vegetable plot	m^2	P	1000 (calculated from parameters in Site Layout Form)	Assumption	NR	NR	NR	NR	NR	Area for growing fruit, grain, and non-leafy vegetables.
Fraction of area of fruit, grain, and non-leafy vegetable plot directly over primary contamination	—	P	0	Assumption	NR	NR	NR	NR	NR	Fraction of the growing area directly over primary contamination.

[a] For truncated lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution, parameter 3 = lower quantile, and parameter 4 = upper quantile; for lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution; for triangular distribution, parameter 1 = minimum, parameter 2 = mode or most likely, and parameter 3 = maximum; for truncated normal distribution, parameter 1 = mean, parameter 2 = standard deviation, parameter 3 = lower quantile, and parameter 4 = upper quantile; for bounded lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution, parameter 3 = minimum value, and parameter 4 = maximum value; for uniform distribution, parameter 1 = minimum, and parameter 2 = maximum; for continuous linear distribution, number of points, value of points, and CDF of points; for continuous logarithmic distribution, number of points, value of points, and CDF of points.

[b] P = physical, B= behavioral, and M = metabolic parameter.

[c] NR = not required.

Table B-57 Base Values and Statistical Distributions of Input Parameters Used in the RESRAD-OFFSITE Code for Offsite Resident via Air Transport Scenario Analysis (cont.)

Input screen title/parameter	Units	Type[b]	Base value for deterministic calculation	Source	Probabilistic analysis[a]					Description
					Distribution	Parameter 1	Parameter 2	Parameter 3	Parameter 4	
Agricultural Areas (cont.)										
Irrigation applied per year on fruit, grain, and non-leafy vegetable plot	m/yr	B	0.2	For deterministic run, base value selected is the code default. For probabilistic run, the minimum being 1/2 of the base value, and the maximum being two times the base value.	Uniform	0.1	0.4			See primary contamination irrigation rate
Evapotranspiration coefficient of fruit, grain, and non-leafy vegetable plot	—	P	0.5	For deterministic run, base value selected is the code default. For probabilistic run, +/ - 50 percent of deterministic value is used.	Uniform,	0.25	0.75			See primary contamination evapotranspiration coefficient.
Runoff coefficient of fruit, grain, and non-leafy vegetable plot	—	P	0.2	For deterministic run, base value selected is the code default. For probabilistic run, distribution from Yu et al. 2007 is used.	Uniform	0.1	0.8			See primary contamination runoff coefficient.
Depth of soil mixing layer of fruit, grain, and non-leafy vegetable plot	m	P	0.15	For deterministic run, base value selected is the code default. For probabilistic run, distribution from Yu et al. 2007 is used.	Triangular	0	0.15	0.6		See primary contamination depth of soil mixing layer.

[a] For truncated lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution, parameter 3 = lower quantile, and parameter 4 = upper quantile; for lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution; for triangular distribution, parameter 1 = minimum, parameter 2 = mode or most likely, and parameter 3 = maximum; for truncated normal distribution, parameter 1 = mean, parameter 2 = standard deviation, parameter 3 = lower quantile, and parameter 4 = upper quantile; for bounded lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution, parameter 3 = minimum value, and parameter 4 = maximum value; for uniform distribution, parameter 1 = minimum, and parameter 2 = maximum; for continuous linear distribution, number of points, value of points, and CDF of points; for continuous logarithmic distribution, number of points, value of points, and CDF of points.

[b] P = physical, B= behavioral, and M = metabolic parameter.

[c] NR = not required.

Table B-57 Base Values and Statistical Distributions of Input Parameters Used in the RESRAD-OFFSITE Code for Offsite Resident via Air Transport Scenario Analysis (cont.)

Input screen title/parameter	Units	Type[b]	Base value for deterministic calculation	Source	Probabilistic analysis[a]					Description
					Distribution	Parameter 1	Parameter 2	Parameter 3	Parameter 4	
Agricultural Areas (cont.)										
Volumetric water content of fruit, grain, and non-leafy vegetable plot	—	P	0.3	For deterministic run, base value selected is the code default. For probabilistic run, distribution from Yu et al. 2007 is used.	Continuous linear					See volumetric water content of clean cover.
Erosion rate of fruit, grain, and non-leafy vegetable plot	m/yr	NA	1.132E-5 (calculated)							Calculated
Dry bulk density of soil of fruit, grain, and non-leafy vegetable plot	g/cm^3	P	1.52	For deterministic run, base value selected is the code default. For probabilistic run, distribution from Yu et al. 2007 is used.	Truncated normal	1.52	0.23	0.001	0.999	See dry bulk density of clean cover.
Soil erodibility factor of fruit, grain, and non-leafy vegetable plot	tons/acre	P	0.4	For deterministic run, base value selected is the code default. For probabilistic run, distribution from Yu et al. 2007 is used.	Continuous linear					See soil erodibility factor of clean cover.
Slope-length-steepness factor of fruit, grain, and non-leafy vegetable plot	—	P	0.4	For deterministic run, base value selected is the code default. For probabilistic run, distribution from Yu et al. 2007 is used.	Continuous linear					See primary contamination slope-length-steepness factor.

[a] For truncated lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution, parameter 3 = lower quantile, and parameter 4 = upper quantile; for lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution; for triangular distribution, parameter 1 = minimum, parameter 2 = mode or most likely, and parameter 3 = maximum; for truncated normal distribution, parameter 1 = mean, parameter 2 = standard deviation, parameter 3 = lower quantile, and parameter 4 = upper quantile; for bounded lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution, parameter 3 = minimum value, and parameter 4 = maximum value; for uniform distribution, parameter 1 = minimum, and parameter 2 = maximum; for continuous linear distribution, number of points, value of points, and CDF of points; for continuous logarithmic distribution, number of points, value of points, and CDF of points.
[b] P = physical, B= behavioral, and M = metabolic parameter.
[c] NR = not required.

Table B-57 Base Values and Statistical Distributions of Input Parameters Used in the RESRAD-OFFSITE Code for Offsite Resident via Air Transport Scenario Analysis (cont.)

Input screen title/parameter	Units	Type[b]	Base value for deterministic calculation	Source	Probabilistic analysis[a]					Description
					Distribution	Parameter 1	Parameter 2	Parameter 3	Parameter 4	
Agricultural Areas (cont.)										
Cover and management factor of fruit, grain, and non-leafy vegetable plot	—	B, P	0.003	For deterministic run, base value selected is the code default. For probabilistic run, distribution from Yu et al. 2007 is used.	Continuous linear					See primary contamination cover and management factor.
Support practice factor of fruit, grain, and non-leafy vegetable plot	—	B, P	1	For deterministic run, base value selected is the code default. For probabilistic run, distribution from Yu et al. 2007 is used.	Continuous linear					See primary contamination support practice factor.
Total porosity of fruit, grain, and non-leafy vegetable plot	—	P	0.425	For deterministic run, base value selected is the mean from the distribution. For probabilistic run, distribution from NUREG/CR-6697 is used.	Truncated normal	0.425	.0867	0.001	0.999	See contaminated zone total porosity.
Sediment from primary contamination delivery ratio	—	P	0							Value carried from Fate of Material Eroded from the Primary Contamination by Runoff Form.
Leafy vegetables field For description see contaminated zone and cover parameters										
Area of leafy vegetable plot	m^2	P	Calculated1000 (calculated from parameters in Site Layout Form)							Area for growing leafy vegetables.

[a] For truncated lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution, parameter 3 = lower quantile, and parameter 4 = upper quantile; for lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution; for triangular distribution, parameter 1 = minimum, parameter 2 = mode or most likely, and parameter 3 = maximum; for truncated normal distribution, parameter 1 = mean, parameter 2 = standard deviation, parameter 3 = lower quantile, and parameter 4 = upper quantile; for bounded lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution, parameter 3 = minimum value, and parameter 4 = maximum value; for uniform distribution, parameter 1 = minimum, and parameter 2 = maximum; for continuous linear distribution, number of points, value of points, and CDF of points; for continuous logarithmic distribution, number of points, value of points, and CDF of points.

[b] P = physical, B= behavioral, and M = metabolic parameter.

[c] NR = not required.

Table B-57 Base Values and Statistical Distributions of Input Parameters Used in the RESRAD-OFFSITE Code for Offsite Resident via Air Transport Scenario Analysis (cont.)

Input screen title/parameter	Units	Type[b]	Base value for deterministic calculation	Source	Probabilistic analysis[a]					Description
					Distribution	Parameter 1	Parameter 2	Parameter 3	Parameter 4	
Leafy vegetables field (cont.) For description see contaminated zone and cover parameters										
Fraction of area of leafy vegetable plot directly over primary contamination	—	P	0							Fraction of the growing area directly over primary contamination.
Irrigation applied per year on leafy vegetable plot	m/yr	B	0.2	For deterministic run, base value selected is the code default. For probabilistic run, the minimum being 1/2 of the base value, and the maximum being two times the base value.	Uniform	0.1	0.4			See primary contamination irrigation rate.
Evapotranspiration coefficient of leafy vegetable plot	—	P	0.5	For deterministic run, base value selected is the code default. For probabilistic run, +/- 50 percent of deterministic value is used.	Uniform	0.25	0.75			See primary contamination evapotranspiration coefficient.
Runoff coefficient of leafy vegetable plot	—	P	0.2	For deterministic run, base value selected is the code default. For probabilistic run, distribution from NUREG/CR-6697 is used.	Uniform	0.1	0.8			See primary contamination runoff coefficient.

[a] For truncated lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution, parameter 3 = lower quantile, and parameter 4 = upper quantile; for lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution; for triangular distribution, parameter 1 = minimum, parameter 2 = mode or most likely, and parameter 3 = maximum; for truncated normal distribution, parameter 1 = mean, parameter 2 = standard deviation, parameter 3 = lower quantile, and parameter 4 = upper quantile; for bounded lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution, parameter 3 = minimum value, and parameter 4 = maximum value; for uniform distribution, parameter 1 = minimum, and parameter 2 = maximum; for continuous linear distribution, number of points, value of points, and CDF of points; for continuous logarithmic distribution, number of points, value of points, and CDF of points.
[b] P = physical, B= behavioral, and M = metabolic parameter.
[c] NR = not required.

Table B-57 Base Values and Statistical Distributions of Input Parameters Used in the RESRAD-OFFSITE Code for Offsite Resident via Air Transport Scenario Analysis (cont.)

Input screen title/parameter	Units	Type[b]	Base value for deterministic calculation	Source	Probabilistic analysis[a]					Description
					Distribution	Parameter 1	Parameter 2	Parameter 3	Parameter 4	
Leafy vegetables field (cont.) For description see contaminated zone and cover parameters										
Depth of soil mixing layer of leafy vegetable plot	m	P	0.15	For deterministic run, base value selected is the median from the distribution. For probabilistic run, distribution from NUREG/CR-6697 is used.	Triangular	0	0.15	0.6		See primary contamination depth of soil mixing layer.
Volumetric water content of leafy vegetable plot	—	P	0.3	For deterministic run, base value selected is the code default. For probabilistic run, distribution from Yu et al. 2007 is used.	Continuous linear					See volumetric water content of clean cover.
Erosion rate of leafy vegetable plot	m/yr	NA	1.132E-5 (calculated)							Calculated
Dry, bulk density of soil of leafy vegetable plot	g/cm^3	P	1.52	For deterministic run, base value selected is the mean from the distribution. For probabilistic run, distribution from NUREG/CR-6697 is used.	Truncated normal	1.52	0.23	0.001	0.999	See dry, bulk density of clean cover.
Soil erodibility factor of leafy vegetable plot	tons/acre	P	0.4	For deterministic run, base value selected is the code default. For probabilistic run, distribution from Yu et al. 2007 is used.	Continuous linear					See soil erodibility factor of clean cover.

[a] For truncated lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution, parameter 3 = lower quantile, and parameter 4 = upper quantile; for lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution; for triangular distribution, parameter 1 = minimum, parameter 2 = mode or most likely, and parameter 3 = maximum; for truncated normal distribution, parameter 1 = mean, parameter 2 = standard deviation, parameter 3 = lower quantile, and parameter 4 = upper quantile; for bounded lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution, parameter 3 = minimum value, and parameter 4 = maximum value; for uniform distribution, parameter 1 = minimum, and parameter 2 = maximum; for continuous linear distribution, number of points, value of points, and CDF of points; for continuous logarithmic distribution, number of points, value of points, and CDF of points.
[b] P = physical, B= behavioral, and M = metabolic parameter.
[c] NR = not required.

Table B-57 Base Values and Statistical Distributions of Input Parameters Used in the RESRAD-OFFSITE Code for Offsite Resident via Air Transport Scenario Analysis (cont.)

Input screen title/parameter	Units	Type[b]	Base value for deterministic calculation	Source	Probabilistic analysis[a]					Description
					Distribution	Parameter 1	Parameter 2	Parameter 3	Parameter 4	
Leafy vegetables field (cont.) For description see contaminated zone and cover parameters										
Slope-length-steepness factor of leafy vegetable plot	—	P	0.4	For deterministic run, base value selected is the code default. For probabilistic run, distribution from Yu et al. 2007 is used.	Continuous linear					See primary contamination slope-length-steepness factor
Cover and management factor of leafy vegetable plot	—	B, P	0.003	For deterministic run, base value selected is the code default. For probabilistic run, distribution from Yu et al. 2007 is used.	Continuous linear					See primary contamination cover and management factor
Support practice factor of leafy vegetable plot	—	B, P	1	For deterministic run, base value selected is the code default. For probabilistic run, distribution from Yu et al. 2007 is used.	Continuous linear					See primary contamination support practice factor
Total porosity of leafy vegetable plot	—	P	0.425	For deterministic run, base value selected is the mean from the distribution.For probabilistic run, distribution from NUREG/CR-6697 is used.	Truncated normal	0.425	.0867	0.001	0.999	See contaminated zone total porosity
Sediment from primary contamination delivery ratio	—	P	0							Value carried from Fate of Material Eroded from the Primary Contamination by Runoff Form

[a] For truncated lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution, parameter 3 = lower quantile, and parameter 4 = upper quantile; for lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution; for triangular distribution, parameter 1 = minimum, parameter 2 = mode or most likely, and parameter 3 = maximum; for truncated normal distribution, parameter 1 = mean, parameter 2 = standard deviation, parameter 3 = lower quantile, and parameter 4 = upper quantile; for bounded lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution, parameter 3 = minimum value, and parameter 4 = maximum value; for uniform distribution, parameter 1 = minimum, and parameter 2 = maximum; for continuous linear distribution, number of points, value of points, and CDF of points; for continuous logarithmic distribution, number of points, value of points, and CDF of points.

[b] P = physical, B= behavioral, and M = metabolic parameter.

[c] NR = not required.

Table B-57 Base Values and Statistical Distributions of Input Parameters Used in the RESRAD-OFFSITE Code for Offsite Resident via Air Transport Scenario Analysis (cont.)

Input screen title/parameter	Units	Type[b]	Base value for deterministic calculation	Source	Probabilistic analysis[a]					Description
					Distribution	Parameter 1	Parameter 2	Parameter 3	Parameter 4	
Livestock Feed Growing Areas										
Pasture and Silage Growing area See description in contaminated zone and cover parameters.										
Area of pasture and silage feed	m^2	P	10,000 (calculated from parameters in Site Layout Form)							Area for growing pasture and silage.
Fraction of area of pasture and silage feed plot directly over primary contamination	—	P	0							Fraction of the growing area directly over primary contamination.
Irrigation applied per year on pasture and silage feed plot	m/yr	B	0.2	For deterministic run, base value selected is the code default. For probabilistic run, the minimum being 1/2 of the base value, and the maximum being two times the base value.	Uniform	0.1	0.4			See primary contamination irrigation rate
Evapotranspiration coefficient of pasture and silage feed plot	—	P	0.5	For deterministic run, base value selected is the code default. For probabilistic run, +/ - 50 percent of deterministic value is used	Uniform	0.25	0.75			See primary contamination evapotranspiration coefficient
Runoff coefficient of pasture and silage feed plot	—	P	0.2	For deterministic run, base value selected is the code default. For probabilistic run, distribution from NUREG/CR-6697 is used.	Uniform	0.1	0.8			See primary contamination runoff coefficient.

[a] For truncated lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution, parameter 3 = lower quantile, and parameter 4 = upper quantile; for lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution; for triangular distribution, parameter 1 = minimum, parameter 2 = mode or most likely, and parameter 3 = maximum; for truncated normal distribution, parameter 1 = mean, parameter 2 = standard deviation, parameter 3 = lower quantile, and parameter 4 = upper quantile; for bounded lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution, parameter 3 = minimum value, and parameter 4 = maximum value; for uniform distribution, parameter 1 = minimum, and parameter 2 = maximum; for continuous linear distribution, number of points, value of points, and CDF of points; for continuous logarithmic distribution, number of points, value of points, and CDF of points.

[b] P = physical, B= behavioral, and M = metabolic parameter.

[c] NR = not required.

Table B-57 Base Values and Statistical Distributions of Input Parameters Used in the RESRAD-OFFSITE Code for Offsite Resident via Air Transport Scenario Analysis (cont.)

Input screen title/parameter	Units	Type[b]	Base value for deterministic calculation	Source	Probabilistic analysis[a]					Description
					Distribution	Parameter 1	Parameter 2	Parameter 3	Parameter 4	
Pasture and Silage Growing area (cont.) See description in contaminated zone and cover parameters.										
Depth of soil mixing layer of pasture and silage feed plot	m	P	0.15	For deterministic run, base value selected is the median from the distribution. For probabilistic run, distribution from NUREG/CR-6697 is used.	Triangular	0	0.15	0.6		See primary contamination depth of soil mixing layer.
Volumetric water content of pasture and silage feed plot	—	P	0.3	For deterministic run, base value selected is the code default. For probabilistic run, distribution from Yu et al. 2007 is used.	Continuous linear					See volumetric water content of clean cover.
Erosion rate of pasture and silage feed plot	m/yr	NA	1.132E-5 (calculated)	Calculated						Calculated
Dry, bulk density of soil of pasture and silage feed plot	g/cm^3	P	1.52	For deterministic run, base value selected is the mean from the distribution. For probabilistic run, distribution from NUREG/CR-6697 is used.	Truncated normal	1.52	0.23	0.001	0.999	See dry, bulk density of clean cover.
Soil erodibility factor of pasture and silage feed plot	tons/acre	P	0.4	For deterministic run, base value selected is the code default. For probabilistic run, distribution from Yu et al. 2007 is used.	Continuous linear					See soil erodibility factor of clean cover.

[a] For truncated lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution, parameter 3 = lower quantile, and parameter 4 = upper quantile; for lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution; for triangular distribution, parameter 1 = minimum, parameter 2 = mode or most likely, and parameter 3 = maximum; for truncated normal distribution, parameter 1 = mean, parameter 2 = standard deviation, parameter 3 = lower quantile, and parameter 4 = upper quantile; for bounded lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution, parameter 3 = minimum value, and parameter 4 = maximum value; for uniform distribution, parameter 1 = minimum, and parameter 2 = maximum; for continuous linear distribution, number of points, value of points, and CDF of points; for continuous logarithmic distribution, number of points, value of points, and CDF of points.

[b] P = physical, B= behavioral, and M = metabolic parameter.

[c] NR = not required.

Table B-57 Base Values and Statistical Distributions of Input Parameters Used in the RESRAD-OFFSITE Code for Offsite Resident via Air Transport Scenario Analysis (cont.)

Input screen title/parameter	Units	Type[b]	Base value for deterministic calculation	Source	Probabilistic analysis[a]					Description
					Distribution	Parameter 1	Parameter 2	Parameter 3	Parameter 4	
Pasture and Silage Growing area (cont.) See description in contaminated zone and cover parameters.										
Slope-length-steepness factor of pasture and silage feed plot	—	P	0.4	For deterministic run, base value selected is the code default. For probabilistic run, distribution from Yu et al. 2007 is used.	Continuous linear					See primary contamination slope-length-steepness factor.
Cover and management factor of pasture and silage feed plot	—	B, P	0.003	For deterministic run, base value selected is the code default. For probabilistic run, distribution from Yu et al. 2007 is used.	Continuous linear					See primary contamination cover and management factor.
Support practice factor of pasture and silage feed plot	—	, P	1	For deterministic run, base value selected is the code default. For probabilistic run, distribution from Yu et al. 2007 is used.	Continuous linear					See primary contamination support practice factor.
Total porosity of pasture and silage feed plot	—	P	0.425	For deterministic run, base value selected is the mean from the distribution. For probabilistic run, distribution from NUREG/CR-6697 is used.	Truncated normal	0.425	.0867	0.001	0.999	See contaminated zone total porosity.
Sediment from primary contamination delivery ratio	—	P	0							Value carried from Fate of Material Eroded from the Primary Contamination by Runoff Form.
Grain Growing area For description see description in contaminated zone and cover parameters.										
Area of grain feed	m^2	P	10,000 (calculated from parameters in Site Layout Form)							Area for growing grain.

[a] For truncated lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution, parameter 3 = lower quantile, and parameter 4 = upper quantile; for lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution; for triangular distribution, parameter 1 = minimum, parameter 2 = mode or most likely, and parameter 3 = maximum; for truncated normal distribution, parameter 1 = mean, parameter 2 = standard deviation, parameter 3 = lower quantile, and parameter 4 = upper quantile; for bounded lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution, parameter 3 = minimum value, and parameter 4 = maximum value; for uniform distribution, parameter 1 = minimum, and parameter 2 = maximum; for continuous linear distribution, number of points, value of points, and CDF of points; for continuous logarithmic distribution, number of points, value of points, and CDF of points.

[b] P = physical, B= behavioral, and M = metabolic parameter.

[c] NR = not required.

Table B-57 Base Values and Statistical Distributions of Input Parameters Used in the RESRAD-OFFSITE Code for Offsite Resident via Air Transport Scenario Analysis (cont.)

Input screen title/parameter	Units	Type[b]	Base value for deterministic calculation	Source	Probabilistic analysis[a]					Description
					Distribution	Parameter 1	Parameter 2	Parameter 3	Parameter 4	
Grain Growing area (cont.) For description see description in contaminated zone and cover parameters.										
Fraction of area of grain feed plot directly over primary contamination	—	P	0							Fraction of the growing area directly over primary contamination.
Irrigation applied per year on grain feed plot	m/yr	B	0.2	For deterministic run, base value selected is the code default. For probabilistic run, the minimum being 1/2 of the base value, and the maximum being two times the base value.	Uniform	0.1	0.3			See primary contamination irrigation rate.
Evapotranspiration coefficient of grain feed plot	—	P	0.5	For deterministic run, base value selected is the code default. For probabilistic run, +/ - 50 percent of deterministic value is used	Uniform	0.25	0.75			See primary contamination evapotranspiration coefficient.
Runoff coefficient of grain feed plot	—	P	0.2	For deterministic run, base value selected is the code default. For probabilistic run, distribution from NUREG/CR-6697 is used.	Uniform	0.1	0.8			See primary contamination runoff coefficient.
Depth of soil mixing layer of grain feed plot	m	P	0.15	For deterministic run, base value selected is the median from the distribution. For probabilistic run, distribution from NUREG/CR-6697 is used.	Triangular	0	0.15	0.6		See primary contamination depth of soil mixing layer.

[a] For truncated lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution, parameter 3 = lower quantile, and parameter 4 = upper quantile; for lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution; for triangular distribution, parameter 1 = minimum, parameter 2 = mode or most likely, and parameter 3 = maximum; for truncated normal distribution, parameter 1 = mean, parameter 2 = standard deviation, parameter 3 = lower quantile, and parameter 4 = upper quantile; for bounded lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution, parameter 3 = minimum value, and parameter 4 = maximum value; for uniform distribution, parameter 1 = minimum, and parameter 2 = maximum; for continuous linear distribution, number of points, value of points, and CDF of points; for continuous logarithmic distribution, number of points, value of points, and CDF of points.

[b] P = physical, B= behavioral, and M = metabolic parameter.

[c] NR = not required.

Table B-57 Base Values and Statistical Distributions of Input Parameters Used in the RESRAD-OFFSITE Code for Offsite Resident via Air Transport Scenario Analysis (cont.)

Input screen title/parameter	Units	Type[b]	Base value for deterministic calculation	Source	Probabilistic analysis[a]					Description
					Distribution	Parameter 1	Parameter 2	Parameter 3	Parameter 4	
Grain Growing area (cont.) For description see description in contaminated zone and cover parameters.										
Volumetric water content of grain feed plot	—	P	0.3	For deterministic run, base value selected is the code default. For probabilistic run, distribution from Yu et al. 2007 is used.	Continuous linear					See volumetric water content of clean cover.
Erosion rate of grain feed plot	m/yr	NA	1.132E-5 (calculated)							Calculated
Dry, bulk density of soil of grain feed plot	g/cm^3	P	1.52	For deterministic run, base value selected is the mean from the distribution. For probabilistic run, distribution from NUREG/CR-6697 is used.	Truncated normal	1.52	0.23	0.001	0.999	See dry, bulk density of clean cover.
Soil erodibility factor of grain feed plot	tons/acre	P	0.4	For deterministic run, the base selected is the code default. For probabilistic run, distribution from Yu et al. 2007 is used.	Continuous linear					See soil erodibility factor of clean cover.
Slope-length-steepness factor of grain feed plot	—	P	0.4	For deterministic run, base value selected is the code default. For probabilistic run, distribution from Yu et al. 2007 is used.	Continuous linear					See primary contamination slope-length-steepness factor

[a] For truncated lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution, parameter 3 = lower quantile, and parameter 4 = upper quantile; for lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution; for triangular distribution, parameter 1 = minimum, parameter 2 = mode or most likely, and parameter 3 = maximum; for truncated normal distribution, parameter 1 = mean, parameter 2 = standard deviation, parameter 3 = lower quantile, and parameter 4 = upper quantile; for bounded lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution, parameter 3 = minimum value, and parameter 4 = maximum value; for uniform distribution, parameter 1 = minimum, and parameter 2 = maximum; for continuous linear distribution, number of points, value of points, and CDF of points; for continuous logarithmic distribution, number of points, value of points, and CDF of points.

[b] P = physical, B= behavioral, and M = metabolic parameter.

[c] NR = not required.

Table B-57 Base Values and Statistical Distributions of Input Parameters Used in the RESRAD-OFFSITE Code for Offsite Resident via Air Transport Scenario Analysis (cont.)

Input screen title/parameter	Units	Type[b]	Base value for deterministic calculation	Source	Probabilistic analysis[a]					Description
					Distribution	Parameter 1	Parameter 2	Parameter 3	Parameter 4	
Grain Growing area (cont.) For description see description in contaminated zone and cover parameters.										
Cover and management factor of grain feed plot	—	B, P	0.003	For deterministic run, base value selected is the code default. For probabilistic run, distribution from Yu et al. 2007 is used.	Continuous linear					See primary contamination cover and management factor.
Support practice factor of grain feed plot	—	B, P	1	For deterministic run, base value selected is the code default. For probabilistic run, distribution from Yu et al. 2007 is used.	Continuous linear					See primary contamination support practice factor.
Total porosity of grain feed plot	—	P	0.425	For deterministic run, base value selected is the mean from the distribution. For probabilistic run, distribution from NUREG/CR-6697 is used.	Truncated normal	0.425	.0867	0.001	0.999	See contaminated zone total porosity.
Sediment from primary contamination delivery ratio	—	P	0							Value carried from Fate of Material Eroded from the Primary Contamination by Runoff Form
Offsite Dwelling Area										
Area of offsite dwelling	m^2	P	1000 (calculated from parameters in Site Layout Form)							

[a] For truncated lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution, parameter 3 = lower quantile, and parameter 4 = upper quantile; for lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution; for triangular distribution, parameter 1 = minimum, parameter 2 = mode or most likely, and parameter 3 = maximum; for truncated normal distribution, parameter 1 = mean, parameter 2 = standard deviation, parameter 3 = lower quantile, and parameter 4 = upper quantile; for bounded lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution, parameter 3 = minimum value, and parameter 4 = maximum value; for uniform distribution, parameter 1 = minimum, and parameter 2 = maximum; for continuous linear distribution, number of points, value of points, and CDF of points; for continuous logarithmic distribution, number of points, value of points, and CDF of points.
[b] P = physical, B= behavioral, and M = metabolic parameter.
[c] NR = not required.

Table B-57 Base Values and Statistical Distributions of Input Parameters Used in the RESRAD-OFFSITE Code for Offsite Resident via Air Transport Scenario Analysis (cont.)

Input screen title/parameter	Units	Type[b]	Base value for deterministic calculation	Source	Probabilistic analysis[a]					Description
					Distribution	Parameter 1	Parameter 2	Parameter 3	Parameter 4	
Offsite Dwelling Area (cont.)										
Irrigation applied per year on offsite dwelling area	m/yr	B	0.2	For deterministic run, base value selected is the code default. For probabilistic run, the minimum being 1/2 of the base value, and the maximum being two times the base value.	Uniform	0.1	0.4			See primary contamination irrigation rate.
Evapotranspiration coefficient of offsite dwelling area	—	P	0.5	For deterministic run, base value selected is the code default.	None	NR	NR	NR	NR	See primary contamination evapotranspiration coefficient.
Runoff coefficient of offsite dwelling area	—	P	0.2	For deterministic run, base value selected is the code default. For probabilistic run, distribution from NUREG/CR-6697 is used.	Uniform	0.1	0.8			See primary contamination runoff coefficient.
Depth of soil mixing layer of offsite dwelling area	m	P	0.15	For deterministic run, base value selected is the median from the distribution. For probabilistic run, distribution from NUREG/CR-6697 is used.	Triangular	0	0.15	0.6		See primary contamination depth of soil mixing layer.

[a] For truncated lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution, parameter 3 = lower quantile, and parameter 4 = upper quantile; for lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution; for triangular distribution, parameter 1 = minimum, parameter 2 = mode or most likely, and parameter 3 = maximum; for truncated normal distribution, parameter 1 = mean, parameter 2 = standard deviation, parameter 3 = lower quantile, and parameter 4 = upper quantile; for bounded lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution, parameter 3 = minimum value, and parameter 4 = maximum value; for uniform distribution, parameter 1 = minimum, and parameter 2 = maximum; for continuous linear distribution, number of points, value of points, and CDF of points; for continuous logarithmic distribution, number of points, value of points, and CDF of points.

[b] P = physical, B= behavioral, and M = metabolic parameter.

[c] NR = not required.

Table B-57 Base Values and Statistical Distributions of Input Parameters Used in the RESRAD-OFFSITE Code for Offsite Resident via Air Transport Scenario Analysis (cont.)

Input screen title/parameter	Units	Type[b]	Base value for deterministic calculation	Source	Probabilistic analysis[a]					Description
					Distribution	Parameter 1	Parameter 2	Parameter 3	Parameter 4	
Offsite Dwelling Area (cont.)										
Volumetric water content of offsite dwelling area	—	P	0.3	For deterministic run, base value selected is the code default. For probabilistic run, distribution from Yu et al. 2007 is used.	Continuous linear					See volumetric water content of clean cover.
Erosion rate of offsite dwelling area	m/yr	NA	0	For deterministic run, base value selected is the code default.	None	NR	NR	NR	NR	Calculated
Dry bulk density of soil of offsite dwelling area	g/cm^3	P	1.52	For deterministic run, base value selected is the mean from the distribution. For probabilistic run, distribution from NUREG/CR-6697 is used.	Truncated normal	1.52	0.23	0.001	0.999	See dry, bulk density of clean cover.
Soil erodibility factor of offsite dwelling area	tons/acre	P	0	For deterministic run, base value selected is the code default.	None	NR	NR	NR	NR	See soil erodibility factor of clean cover.
Slope-length-steepness factor of offsite dwelling area	—	P	0.4	For deterministic run, base value selected is the code default.	None	NR	NR	NR	NR	See primary contamination slope-length-steepness factor.
Cover and management factor of offsite dwelling area	—	B, P	0.003	For deterministic run, base value selected is the code default. For probabilistic run, distribution from Yu et al. 2007 is used.	Continuous linear					See primary contamination cover and management factor.

[a] For truncated lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution, parameter 3 = lower quantile, and parameter 4 = upper quantile; for lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution; for triangular distribution, parameter 1 = minimum, parameter 2 = mode or most likely, and parameter 3 = maximum; for truncated normal distribution, parameter 1 = mean, parameter 2 = standard deviation, parameter 3 = lower quantile, and parameter 4 = upper quantile; for bounded lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution, parameter 3 = minimum value, and parameter 4 = maximum value; for uniform distribution, parameter 1 = minimum, and parameter 2 = maximum; for continuous linear distribution, number of points, value of points, and CDF of points; for continuous logarithmic distribution, number of points, value of points, and CDF of points.

[b] P = physical, B= behavioral, and M = metabolic parameter.

[c] NR = not required.

Table B-57 Base Values and Statistical Distributions of Input Parameters Used in the RESRAD-OFFSITE Code for Offsite Resident via Air Transport Scenario Analysis (cont.)

Input screen title/parameter	Units	Type[b]	Base value for deterministic calculation	Source	Probabilistic analysis[a]					Description
					Distribution	Parameter 1	Parameter 2	Parameter 3	Parameter 4	
Offsite Dwelling Area (cont.)										
Support practice factor of offsite dwelling area	—	B, P	1	For deterministic run, base value selected is the code default. For probabilistic run, distribution from Yu et al. 2007 is used.	Continuous linear					See primary contamination support practice factor.
Total porosity of offsite dwelling area	—	P	0.425	For deterministic run, base value selected is the mean from the distribution. For probabilistic run, distribution from NUREG/CR-6697 is used.	Truncated normal	0.425	.0867	0.001	0.999	See contaminated zone total porosity.
Sediment from primary contamination delivery ratio	—	P	0							Value carried from Fate of Material Eroded from the Primary Contamination by Runoff Form
Atmospheric Transport										
Release height	m	P	1	For deterministic run, base value selected is the code default.	None	NR	NR	NR	NR	Physical release height of escaped material.
Release heat flux	cal/s	P	0	For deterministic run, base value selected is the code default.	None	NR	NR	NR	NR	The heat energy associated with the contaminant release.
Anemometer height	m	P	10	For deterministic run, base value selected is the code default.	None	NR	NR	NR	NR	The height at which the value for wind speed is measured.
Ambient temperature	K	P	285	For deterministic run, base value selected is the code default.	None	NR	NR	NR	NR	Ambient temperature used in the calculation of plume rise of escaped material.

[a] For truncated lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution, parameter 3 = lower quantile, and parameter 4 = upper quantile; for lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution; for triangular distribution, parameter 1 = minimum, parameter 2 = mode or most likely, and parameter 3 = maximum; for truncated normal distribution, parameter 1 = mean, parameter 2 = standard deviation, parameter 3 = lower quantile, and parameter 4 = upper quantile; for bounded lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution, parameter 3 = minimum value, and parameter 4 = maximum value; for uniform distribution, parameter 1 = minimum, and parameter 2 = maximum; for continuous linear distribution, number of points, value of points, and CDF of points; for continuous logarithmic distribution, number of points, value of points, and CDF of points.

[b] P = physical, B= behavioral, and M = metabolic parameter.

[c] NR = not required.

Table B-57 Base Values and Statistical Distributions of Input Parameters Used in the RESRAD-OFFSITE Code for Offsite Resident via Air Transport Scenario Analysis (cont.)

Input screen title/parameter	Units	Type[b]	Base value for deterministic calculation	Source	Probabilistic analysis[a]					Description
					Distribution	Parameter 1	Parameter 2	Parameter 3	Parameter 4	
Atmospheric Transport (cont.)										
AM atmospheric mixing height	m	P	400	For deterministic run, base value selected is the code default.	None	NR	NR	NR	NR	The annual average morning mixing height. The annual average morning mixing height and the annual afternoon mixing height are used to determine the mixing height for different Pasquill stability classes.
PM atmospheric mixing height	m	P	1600	For deterministic run, base value selected is the code default.	None	NR	NR	NR	NR	The annual afternoon mixing height.
Dispersion model coefficients	—	P	Pasquill-Gifford Coefficients	For deterministic run, base value selected is the code default.	None	NR	NR	NR	NR	Controls dispersion coefficients used for the plume dispersion calculations. Pasquill-Gifford coefficients used for releases at or near ground level.
Windspeed Terrain	—	P	Rural	For deterministic run, base value selected is the code default.	None	NR	NR	NR	NR	Wind speed terrain selection affects air dispersion.
Elevation of Fruit, grain, non-leafy vegetable plot relative to primary contamination (PC)	m	P	0	For deterministic run, base value selected is the code default.	None	NR	NR	NR	NR	When the ground level at the offsite location is above the ground level at the vicinity of the primary contamination, the code adjusts for the upward deflection of the wind. The difference in the height of the ground surface at the off-site location of contaminant accumulation and its height around the site of primary contamination.
Elevation of leafy vegetable plot relative to PC	m	P	0	For deterministic run, base value selected is the code default.	None	NR	NR	NR	NR	See above.
Elevation of pasture silage growing area relative to PC	m	P	0	For deterministic run, base value selected is the code default.	None	NR	NR	NR	NR	See above.
Elevation of grain fields relative to PC	m	P	0	For deterministic run, base value selected is the code default.	None	NR	NR	NR	NR	See above.

[a] For truncated lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution, parameter 3 = lower quantile, and parameter 4 = upper quantile; for lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution; for triangular distribution, parameter 1 = minimum, parameter 2 = mode or most likely, and parameter 3 = maximum; for truncated normal distribution, parameter 1 = mean, parameter 2 = standard deviation, parameter 3 = lower quantile, and parameter 4 = upper quantile; for bounded lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution, parameter 3 = minimum value, and parameter 4 = maximum value; for uniform distribution, parameter 1 = minimum, and parameter 2 = maximum; for continuous linear distribution, number of points, value of points, and CDF of points; for continuous logarithmic distribution, number of points, value of points, and CDF of points.

[b] P = physical, B= behavioral, and M = metabolic parameter.

[c] NR = not required.

Table B-57 Base Values and Statistical Distributions of Input Parameters Used in the RESRAD-OFFSITE Code for Offsite Resident via Air Transport Scenario Analysis (cont.)

Input screen title/parameter	Units	Type[b]	Base value for deterministic calculation	Source	Probabilistic analysis[a]					Description
					Distribution	Parameter 1	Parameter 2	Parameter 3	Parameter 4	
Atmospheric Transport (cont.)										
Elevation of dwelling site relative to PC	m	P	0	For deterministic run, base value selected is the code default.	None	NR	NR	NR	NR	See above.
Elevation of surface water body relative to PC	m	P	0	For deterministic run, base value selected is the code default.	None	NR	NR	NR	NR	See above.
Grid spacing for areal integration	m	NA	10	For deterministic run, base value selected is the code default.	None	NR	NR	NR	NR	See above.
Joint frequency of wind speed and stability class for a 16-sector wind rose	—	P	Input value							Wind blowing with average speed of 0.89 m/s from S to N in stability classes D, E, and F in 0.1, 0.2, and 0.7 fractions, respectively. For the receptor and accumulation locations in this scenario, the wind blowing from S to N in stability classes D, E, and F will give a higher dose for a near ground level release as there is less dispersion in these cases.
Unsaturated Zone Hydrology										
Number of unsaturated zones	—	P	1	For deterministic run, base value selected is the code default.	None	NR	NR	NR	NR	
Unsaturated zone thickness	m	P	4	For deterministic run, base value selected is the code default. For probabilistic run, distribution from NUREG/CR-6697 is used.	Bounded lognormal-N	2.296	1.276	0.18	320	The thickness of the specific unsaturated zone.

[a] For truncated lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution, parameter 3 = lower quantile, and parameter 4 = upper quantile; for lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution; for triangular distribution, parameter 1 = minimum, parameter 2 = mode or most likely, and parameter 3 = maximum; for truncated normal distribution, parameter 1 = mean, parameter 2 = standard deviation, parameter 3 = lower quantile, and parameter 4 = upper quantile; for bounded lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution, parameter 3 = minimum value, and parameter 4 = maximum value; for uniform distribution, parameter 1 = minimum, and parameter 2 = maximum; for continuous linear distribution, number of points, value of points, and CDF of points; for continuous logarithmic distribution, number of points, value of points, and CDF of points.

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[c] NR = not required.

Table B-57 Base Values and Statistical Distributions of Input Parameters Used in the RESRAD-OFFSITE Code for Offsite Resident via Air Transport Scenario Analysis (cont.)

Input screen title/parameter	Units	Type[b]	Base value for deterministic calculation	Source	Probabilistic analysis[a]					Description
					Distribution	Parameter 1	Parameter 2	Parameter 3	Parameter 4	
Unsaturated Zone Hydrology (cont.)										
Unsaturated zone drybulk density	g/cm^3	P	1.52	For deterministic run, base value selected is the mean from the distribution. For probabilistic run, distribution from NUREG/CR-6697 is used.	Truncated normal	1.52	0.23	0.001	0.999	See contaminated zone dry bulk density parameter.
Unsaturated zone total porosity	—	P	0.425	For deterministic run, base value selected is the mean from the distribution. For probabilistic run, distribution from NUREG/CR-6697 is used.	Truncated normal	0.425	.0867	0.001	0.999	See clean cover total porosity parameter.
Unsaturated zone effective porosity	—	P	0.355	For deterministic run, base value selected is the mean from the distribution. For probabilistic run, distribution from NUREG/CR-6697 is used.	Truncated normal	0.355	0.0906	0.001	0.999	The effective porosity of the unsaturated zone is the ratio of the pore volume where water can circulate to the total volume of the unsaturated zone. Used along with other hydrological parameters to calculate the water transport breakthrough times.
Unsaturated zone field capacity	—	P	0.3	Code default	None	NR	NR	NR	NR	See contaminated zone field capacity parameter.
Unsaturated zone hydraulic conductivity	m/yr	P	10	The code default	Bounded lognormal-N	2.3	2.11	0.004	9250	See contaminated zone hydraulic conductivity parameter.

[a] For truncated lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution, parameter 3 = lower quantile, and parameter 4 = upper quantile; for lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution; for triangular distribution, parameter 1 = minimum, parameter 2 = mode or most likely, and parameter 3 = maximum; for truncated normal distribution, parameter 1 = mean, parameter 2 = standard deviation, parameter 3 = lower quantile, and parameter 4 = upper quantile; for bounded lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution, parameter 3 = minimum value, and parameter 4 = maximum value; for uniform distribution, parameter 1 = minimum, and parameter 2 = maximum; for continuous linear distribution, number of points, value of points, and CDF of points; for continuous logarithmic distribution, number of points, value of points, and CDF of points.

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[c] NR = not required.

Table B-57 Base Values and Statistical Distributions of Input Parameters Used in the RESRAD-OFFSITE Code for Offsite Resident via Air Transport Scenario Analysis (cont.)

Input screen title/parameter	Units	Type[b]	Base value for deterministic calculation	Source	Probabilistic analysis[a]					Description
					Distribution	Parameter 1	Parameter 2	Parameter 3	Parameter 4	
Unsaturated Zone Hydrology (cont.)										
Unsaturated zone soil b parameter	—	P	5.3	For deterministic run base value selected is the code default. For probabilistic run, distribution from NUREG/CR-6697 is used.	Bounded lognormal-N	1.06	0.66	0.5	30	See contaminated zone soil b parameter.
Unsaturated zone longitudinal dispersivity	m	P	0.1	For deterministic run, base value selected is the code default. For probabilistic run, distribution from Yu et al. 2007 is used.	Continuous linear					The ratio between the longitudinal dispersion coefficient and pore water velocity. This parameter is dependent on the thickness of the zone.
Saturated Zone Hydrology										
Thickness of saturated zone	m	P	100	For deterministic run code default and for probabilistic run uniform distribution from half the default to double the default value.	Uniform	50	200			The thickness of the saturated zone. It is used to model dispersion in the saturated zone in the vertical direction.
Dry, bulk density of saturated zone	g/cm^3	P	1.52	For deterministic run, base value selected is the mean from the distribution. For probabilistic run, distribution from NUREG/CR-6697 is used.	Truncated normal	1.52	0.23	0.001	0.999	See contaminated zone dry bulk density parameter.

[a] For truncated lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution, parameter 3 = lower quantile, and parameter 4 = upper quantile; for lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution; for triangular distribution, parameter 1 = minimum, parameter 2 = mode or most likely, and parameter 3 = maximum; for truncated normal distribution, parameter 1 = mean, parameter 2 = standard deviation, parameter 3 = lower quantile, and parameter 4 = upper quantile; for bounded lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution, parameter 3 = minimum value, and parameter 4 = maximum value; for uniform distribution, parameter 1 = minimum, and parameter 2 = maximum; for continuous linear distribution, number of points, value of points, and CDF of points; for continuous logarithmic distribution, number of points, value of points, and CDF of points.

[b] P = physical, B= behavioral, and M = metabolic parameter.

[c] NR = not required.

Table B-57 Base Values and Statistical Distributions of Input Parameters Used in the RESRAD-OFFSITE Code for Offsite Resident via Air Transport Scenario Analysis (cont.)

Input screen title/parameter	Units	Type[b]	Base value for deterministic calculation	Source	Probabilistic analysis[a]					Description
					Distribution	Parameter 1	Parameter 2	Parameter 3	Parameter 4	
Saturated Zone Hydrology (cont.)										
Saturated zone total porosity	—	P	0.425	For deterministic run, base value selected is the mean from the distribution. For probabilistic run, distribution from NUREG/CR-6697 is used.	Truncated normal	0.425	.0867	0.001	0.999	See clean cover total porosity parameter.
Saturated zone effective porosity	—	P	0.355	For deterministic run, base value selected is the mean from the distribution. For probabilistic run, distribution from NUREG/CR-6697 is used.	Truncated normal	0.355	0.0906	0.001	0.999	See unsaturated zone effective porosity parameter.
Saturated zone hydraulic conductivity	m/yr	P	81	For deterministic run, base value selected is the mean from the distribution. For probabilistic run, distribution from NUREG/CR-6697 is used.	Bounded lognormal-N	2.3	2.11	0.004	9250	See contaminated zone hydraulic conductivity parameter.
Saturated zone hydraulic gradient to well	—	P	0.02	For deterministic run, base value selected is the code default. For probabilistic run, distribution from NUREG/CR-6697 is used.	Bounded lognormal-N	-5.11	1.77	0.00007	0.5	The slope of the surface of the water table. The hydraulic gradient is one of several hydrogeological parameters used in water transport calculations.

[a] For truncated lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution, parameter 3 = lower quantile, and parameter 4 = upper quantile; for lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution; for triangular distribution, parameter 1 = minimum, parameter 2 = mode or most likely, and parameter 3 = maximum; for truncated normal distribution, parameter 1 = mean, parameter 2 = standard deviation, parameter 3 = lower quantile, and parameter 4 = upper quantile; for bounded lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution, parameter 3 = minimum value, and parameter 4 = maximum value; for uniform distribution, parameter 1 = minimum, and parameter 2 = maximum; for continuous linear distribution, number of points, value of points, and CDF of points; for continuous logarithmic distribution, number of points, value of points, and CDF of points.

[b] P = physical, B= behavioral, and M = metabolic parameter.

[c] NR = not required.

Table B-57 Base Values and Statistical Distributions of Input Parameters Used in the RESRAD-OFFSITE Code for Offsite Resident via Air Transport Scenario Analysis (cont.)

Input screen title/parameter	Units	Type[b]	Base value for deterministic calculation	Source	Probabilistic analysis[a]					Description
					Distribution	Parameter 1	Parameter 2	Parameter 3	Parameter 4	
Saturated Zone Hydrology (cont.)										
Depth of aquifer contributing to well	m	P	10	For deterministic run, base value selected is the code default. For probabilistic run, distribution from NUREG/CR-6697 is used.	Triangular	6	10	30		The well is assumed to be fully screened from the water table to the specified well screen depth.
Saturated zone longitudinal dispersivity to well	m	P	3	For deterministic run, base value selected is the code default. For probabilistic run, distribution from Yu et al. 2007 is used.	Continuous linear					See unsaturated zone longitudinal dispersivity parameter.
Saturated zone horizontal lateral dispersivity to well	m	P	0.4	For deterministic run, base value selected is the code default. For probabilistic run, distribution from Yu et al. 2007 is used.	Continuous linear					The ratio between the horizontal lateral dispersion coefficient and pore water velocity. This parameter is usually about a tenth to three tenths of the longitudinal dispersivity.
Saturated zone vertical lateral dispersivity to well	m	P	0.02	For deterministic run, base value selected is the code default. For probabilistic run, distribution from Yu et al. 2007 is used.	Continuous linear					The ratio between the vertical lateral dispersion coefficient and pore water velocity.
Saturated zone hydraulic gradient to surface water body	—	P	0.02	For deterministic run, base value selected is the code default. For probabilistic run, distribution from NUREG/CR-6697 is used.	Bounded lognormal-N	-5.11	1.77	0.00007	0.5	The slope of the surface of the water table. The hydraulic gradient is one of several hydrogeological parameters used in water transport calculations.

[a] For truncated lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution, parameter 3 = lower quantile, and parameter 4 = upper quantile; for lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution; for triangular distribution, parameter 1 = minimum, parameter 2 = mode or most likely, and parameter 3 = maximum; for truncated normal distribution, parameter 1 = mean, parameter 2 = standard deviation, parameter 3 = lower quantile, and parameter 4 = upper quantile; for bounded lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution, parameter 3 = minimum value, and parameter 4 = maximum value; for uniform distribution, parameter 1 = minimum, and parameter 2 = maximum; for continuous linear distribution, number of points, value of points, and CDF of points; for continuous logarithmic distribution, number of points, value of points, and CDF of points.

[b] P = physical, B= behavioral, and M = metabolic parameter.

[c] NR = not required.

Table B-57 Base Values and Statistical Distributions of Input Parameters Used in the RESRAD-OFFSITE Code for Offsite Resident via Air Transport Scenario Analysis (cont.)

Input screen title/parameter	Units	Type[b]	Base value for deterministic calculation	Source	Probabilistic analysis[a]					Description
					Distribution	Parameter 1	Parameter 2	Parameter 3	Parameter 4	
Saturated Zone Hydrology (cont.)										
Depth of aquifer contributing to surface water body	m	P	10	For deterministic run, base value selected is the code default. For probabilistic run, distribution from NUREG/CR-6697 is used.	Uniform	5	20			The depth of the aquifer that flows into the surface water body. If water flows in the opposite direction (from the surface water body into the aquifer) this depth would be zero. This depth calculates the contaminant flux reaching the surface water body by way of the aquifer.
Saturated zone longitudinal dispersivity to surface water body	m	P	10	For deterministic run, base value selected is the code default. For probabilistic run, distribution from Yu et al. 2007 is used.	Continuous linear					See unsaturated zone longitudinal dispersivity parameter.
Saturated zone horizontal lateral dispersivity to surface water body	m	P	1	For deterministic run, base value selected is the code default. For probabilistic run, distribution from Yu et al. 2007 is used.	Continuous linear					The ratio between the horizontal lateral dispersion coefficient and pore water velocity. This parameter is usually about a tenth to three-tenths of the longitudinal dispersivity.
Saturated zone vertical lateral dispersivity to surface water body	m	P	0.06	For deterministic run, base value selected is the code default. For probabilistic run, distribution from Yu et al. 2007 is used.	Continuous linear					The ratio between the vertical lateral dispersion coefficient and pore water velocity.
Water Use										
Consumption by humans										
Quantity of water consumed by an individual	L/yr	M, B	510	Code default	NR	NR	NR	NR	NR	The total amount of water consumed by an individual; it includes water used in the preparation of and consumed with food.

[a] For truncated lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution, parameter 3 = lower quantile, and parameter 4 = upper quantile; for lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution; for triangular distribution, parameter 1 = minimum, parameter 2 = mode or most likely, and parameter 3 = maximum; for truncated normal distribution, parameter 1 = mean, parameter 2 = standard deviation, parameter 3 = lower quantile, and parameter 4 = upper quantile; for bounded lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution, parameter 3 = minimum value, and parameter 4 = maximum value; for uniform distribution, parameter 1 = minimum, and parameter 2 = maximum; for continuous linear distribution, number of points, value of points, and CDF of points; for continuous logarithmic distribution, number of points, value of points, and CDF of points.

[b] P = physical, B= behavioral, and M = metabolic parameter.

[c] NR = not required.

Table B-57 Base Values and Statistical Distributions of Input Parameters Used in the RESRAD-OFFSITE Code for Offsite Resident via Air Transport Scenario Analysis (cont.)

Input screen title/parameter	Units	Type[b]	Base value for deterministic calculation	Source	Probabilistic analysis[a]					Description
					Distribution	Parameter 1	Parameter 2	Parameter 3	Parameter 4	
Consumption by humans (cont.)										
Fraction of water from surface body for consumption by humans	—	B, P	1	Assumption	NR	NR	NR	NR	NR	The fraction of water consumed by humans obtained from the surface water source.
Fraction of water from well for consumption by humans	—	B, P	0	Assumption	NR	NR	NR	NR	NR	The fraction of water consumed by humans obtained from the well.
Number of household individuals consuming and using water	—	B	4	Code default	NR	NR	NR	NR	NR	Number of household individuals for calculating water use.
Use indoors of dwelling										
Quantity of water for use indoors of dwelling per individual	L/yr	M, B	225	Code default	NR	NR	NR	NR	NR	The total amount of water used indoors by an individual for bathing, laundry, washing, etc. This quantity is used to estimate the volume of water that needs to be extracted from the well to satisfy the specified needs.
Fraction of water from surface body for use indoors of dwelling	—	B, P	1	Assumption	NR	NR	NR	NR	NR	The fraction of water used in the dwelling obtained from the surface water source is used in the computation of indoor radon.
Fraction of water from well for use indoors of dwelling	—	B, P	0	Assumption	NR	NR	NR	NR	NR	The fraction of water used in the dwelling obtained from the well. This factor is used in the computation of indoor radon.
Number of household individuals for household purposes	—	B	4	Code default	NR	NR	NR	NR	NR	Number of household individuals for calculating water use.
Beef cattle										
Quantity of water for beef cattle	L/yr	M	50	Code default	NR	NR	NR	NR	NR	The daily intake of water by beef cattle kept for meat production.
Fraction of water from surface body for beef cattle	—	B, P	1	Assumption	NR	NR	NR	NR	NR	The fraction of water consumed by beef cattle raised for meat obtained from the surface water source.
Fraction of water from well for beef cattle	—	B, P	0	Assumption	NR	NR	NR	NR	NR	The fraction of water consumed by beef cattle raised for meat obtained from the well water source.
Number of cattle for beef cattle	—	B	2	Code default	NR	NR	NR	NR	NR	Number of beef cattle for calculating water use.

[a] For truncated lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution, parameter 3 = lower quantile, and parameter 4 = upper quantile; for lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution; for triangular distribution, parameter 1 = minimum, parameter 2 = mode or most likely, and parameter 3 = maximum; for truncated normal distribution, parameter 1 = mean, parameter 2 = standard deviation, parameter 3 = lower quantile, and parameter 4 = upper quantile; for bounded lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution, parameter 3 = minimum value, and parameter 4 = maximum value; for uniform distribution, parameter 1 = minimum, and parameter 2 = maximum; for continuous linear distribution, number of points, value of points, and CDF of points; for continuous logarithmic distribution, number of points, value of points, and CDF of points.

[b] P = physical, B= behavioral, and M = metabolic parameter.

[c] NR = not required.

Table B-57 Base Values and Statistical Distributions of Input Parameters Used in the RESRAD-OFFSITE Code for Offsite Resident via Air Transport Scenario Analysis (cont.)

Input screen title/parameter	Units	Type[b]	Base value for deterministic calculation	Source	Probabilistic analysis[a]					Description
					Distribution	Parameter 1	Parameter 2	Parameter 3	Parameter 4	
Dairy cows										
Quantity of water for dairy cows	L/yr	M	160	Code default	NR	NR	NR	NR	NR	The daily intake of water by dairy cows kept for milk production.
Fraction of water from surface body for dairy cows	—	B, P	1	Assumption	NR	NR	NR	NR	NR	The fraction of water consumed by dairy cows raised for milk obtained from the surface water source.
Fraction of water from well for dairy cows	—	B, P	0	Assumption	NR	NR	NR	NR	NR	The fraction of water consumed by dairy cows raised for milk obtained from the well water source.
Number of cows for dairy cows	—	B	2	Code default	NR	NR	NR	NR	NR	Number of dairy cows for calculating water use.
Fruit, grain, non-leafy vegetables										
Quantity of irrigation for fruit, grain, and non-leafy vegetables	m/yr	B	0.2	For deterministic run, base value selected is the code default. For probabilistic run, the minimum being 1/2 of the base value, and the maximum being two times the base value.	Uniform	0.1	0.4	NR	NR	The amount of irrigation applied on an area used to produce leafy vegetables.
Fraction of water from surface body for fruit, grain, and non-leafy vegetables	—	B, P	1	Assumption	NR	NR	NR	NR	NR	The fraction of irrigation water applied at fruit, grain, and non-leafy vegetable field obtained from the surface water source.
Fraction of water from well for fruit, grain, and non-leafy vegetables	—	B, P	0	Assumption	NR	NR	NR	NR	NR	The fraction of irrigation water applied at fruit, grain, and non-leafy vegetable field obtained from the well.
Area of plot for fruit, grain, and non-leafy vegetables	m^2	B	1000 (calculated from parameters in Site Layout Form)							The area of the plot used to produce fruit, grain, and non-leafy vegetables where irrigation is applied.

[a] For truncated lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution, parameter 3 = lower quantile, and parameter 4 = upper quantile; for lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution; for triangular distribution, parameter 1 = minimum, parameter 2 = mode or most likely, and parameter 3 = maximum; for truncated normal distribution, parameter 1 = mean, parameter 2 = standard deviation, parameter 3 = lower quantile, and parameter 4 = upper quantile; for bounded lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution, parameter 3 = minimum value, and parameter 4 = maximum value; for uniform distribution, parameter 1 = minimum, and parameter 2 = maximum; for continuous linear distribution, number of points, value of points, and CDF of points; for continuous logarithmic distribution, number of points, value of points, and CDF of points.

[b] P = physical, B= behavioral, and M = metabolic parameter.

[c] NR = not required.

Table B-57 Base Values and Statistical Distributions of Input Parameters Used in the RESRAD-OFFSITE Code for Offsite Resident via Air Transport Scenario Analysis (cont.)

Input screen title/parameter	Units	Type[b]	Base value for deterministic calculation	Source	Probabilistic analysis[a]					Description
					Distribution	Parameter 1	Parameter 2	Parameter 3	Parameter 4	
Leafy vegetables										
Quantity of irrigation for leafy vegetables	m/yr	B	0.2	For deterministic run, base value selected is the code default. For probabilistic run, the minimum being 1/2 of the base value, and the maximum being two times the base value.	Uniform	0.1	0.4	NR	NR	The amount of irrigation applied on an area used to produce leafy vegetables.
Fraction of water from surface body for leafy vegetables	—	B, P	1	Assumption	NR	NR	NR	NR	NR	The fraction of irrigation water applied at leafy vegetable field obtained from the surface water source.
Fraction of water from well for leafy vegetables	—	B, P	0	Assumption	NR	NR	NR	NR	NR	The fraction of irrigation water applied at leafy vegetable field obtained from the well.
Area of plot for leafy vegetables	m^2	B	1000 (calculated from parameters in Site Layout Form)							The area of the plot used to produce leafy vegetables where irrigation is applied.
Pasture, Silage										
Quantity of irrigation for pasture and silage	m/yr	B	0.2	For deterministic run, base value selected is the code default. For probabilistic run, the minimum being 1/2 of the base value, and the maximum being two times the base value.	Uniform	0.1	0.4	NR	NR	The amount of irrigation applied on an area used to produce pasture and silage.
Fraction of water from surface body for pasture and silage	—	B, P	1	Assumption	NR	NR	NR	NR	NR	The fraction of irrigation water applied at pasture and silage field obtained from the surface water source.
Fraction of water from well for pasture and silage	—	B, P	0	Assumption	NR	NR	NR	NR	NR	The fraction of irrigation water applied at pasture and silage field obtained from the well.
Area of plot for pasture and silage	m^2	B	10000 (calculated from parameters in Site Layout Form)							The area of the plot used to produce pasture and silage where irrigation is applied.

[a] For truncated lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution, parameter 3 = lower quantile, and parameter 4 = upper quantile; for lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution; for triangular distribution, parameter 1 = minimum, parameter 2 = mode or most likely, and parameter 3 = maximum; for truncated normal distribution, parameter 1 = mean, parameter 2 = standard deviation, parameter 3 = lower quantile, and parameter 4 = upper quantile; for bounded lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution, parameter 3 = minimum value, and parameter 4 = maximum value; for uniform distribution, parameter 1 = minimum, and parameter 2 = maximum; for continuous linear distribution, number of points, value of points, and CDF of points; for continuous logarithmic distribution, number of points, value of points, and CDF of points.

[b] P = physical, B= behavioral, and M = metabolic parameter.

[c] NR = not required.

Table B-57 Base Values and Statistical Distributions of Input Parameters Used in the RESRAD-OFFSITE Code for Offsite Resident via Air Transport Scenario Analysis (cont.)

Input screen title/parameter	Units	Type[b]	Base value for deterministic calculation	Source	Probabilistic analysis[a]					Description
					Distribution	Parameter 1	Parameter 2	Parameter 3	Parameter 4	
Livestock feed grain										
Quantity of irrigation for livestock feed grain	m/yr	B	0.2	For deterministic run, base value selected is the code default. For probabilistic run, the minimum being 1/2 of the base value, and the maximum being two times the base value.	Uniform	0.1	0.4	NR	NR	The amount of irrigation applied on an area used to produce livestock feed grain.
Fraction of water from surface body for livestock feed grain	—	B, P	1	Assumption	NR	NR	NR	NR	NR	The fraction of irrigation water applied at livestock feed grain field obtained from the surface water source.
Fraction of water from well for livestock feed grain	—	B, P	0	Assumption	NR	NR	NR	NR	NR	The fraction of irrigation water applied at livestock feed grain field obtained from the well.
Area of plot for livestock feed grain	m^2	B	10000 (calculated from parameters in Site Layout Form)							The area of the plot used to produce livestock feed grain where irrigation is applied.
Offsite Dwelling site										
Quantity of irrigation for offsite dwelling site	m/yr	B	0.2	For deterministic run, base value selected is the code default. For probabilistic run, the minimum being 1/2 of the base value, and the maximum being two times the base value.	Uniform	0.1	0.4	NR	NR	The amount of irrigation applied on an area used for offsite dwelling site.
Fraction of water from surface body for offsite dwelling site	—	B, P	1	Assumption	NR	NR	NR	NR	NR	The fraction of irrigation water applied at offsite dwelling site obtained from the surface water source.
Fraction of water from well for offsite dwelling site	—	B, P	0	Assumption	NR	NR	NR	NR	NR	The fraction of irrigation water applied offsite dwelling site obtained from the well.

[a] For truncated lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution, parameter 3 = lower quantile, and parameter 4 = upper quantile; for lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution; for triangular distribution, parameter 1 = minimum, parameter 2 = mode or most likely, and parameter 3 = maximum; for truncated normal distribution, parameter 1 = mean, parameter 2 = standard deviation, parameter 3 = lower quantile, and parameter 4 = upper quantile; for bounded lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution, parameter 3 = minimum value, and parameter 4 = maximum value; for uniform distribution, parameter 1 = minimum, and parameter 2 = maximum; for continuous linear distribution, number of points, value of points, and CDF of points; for continuous logarithmic distribution, number of points, value of points, and CDF of points.

[b] P = physical, B= behavioral, and M = metabolic parameter.

[c] NR = not required.

Table B-57 Base Values and Statistical Distributions of Input Parameters Used in the RESRAD-OFFSITE Code for Offsite Resident via Air Transport Scenario Analysis (cont.)

Input screen title/parameter	Units	Type[b]	Base value for deterministic calculation	Source	Probabilistic analysis[a]					Description
					Distribution	Parameter 1	Parameter 2	Parameter 3	Parameter 4	
Offsite Dwelling site (cont.)										
Area of plot for offsite dwelling site	m^2	B	1000 (calculated from parameters in Site Layout Form)							The area of the plot used for offsite dwelling site where irrigation is applied.
Well-pumping rate	m^3/yr	B, P	5100	For deterministic run, base value selected is the code default. For probabilistic run, + /- 50 percent of deterministic value is used	Uniform	2550	7650			The total volume of water withdrawn from the well for all purposes is used to estimate the dilution that occurs in the well.
Well pumping rate needed to support specified water use for livestock feed grain	m^3/yr	B, P	0							Calculated
Surface Water Body										
Surface area of water in surface water body	m^2	NA	90000							Calculated value from the site coordinated in the Site Layout form.
Volume of surface water body	m^3	P	150,000	For deterministic run, base value selected is the code default. For probabilistic run, uniform distribution from half to double the default value is used.	Uniform	75000	300,000			The volume of water in a surface water body.
Potential evaporation	m/yr	P	1	For deterministic run, base value selected is the code default. For probabilistic run, uniform distribution from 0.25 to default value is used.	0.25	1				
Stream outflow (as a fraction of total outflow)		NA	0.9934 (calculated from inflow)							Calculated value from other parameters

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[b] P = physical, B= behavioral, and M = metabolic parameter.

[c] NR = not required.

Table B-57 Base Values and Statistical Distributions of Input Parameters Used in the RESRAD-OFFSITE Code for Offsite Resident via Air Transport Scenario Analysis (cont.)

Input screen title/parameter	Units	Type[b]	Base value for deterministic calculation	Source	Probabilistic analysis[a]					Description
					Distribution	Parameter 1	Parameter 2	Parameter 3	Parameter 4	
Surface Water Body (cont.)										
Settling velocity of sediments	cm/s	P	0.1	For deterministic run, base value selected is the code default. For probabilistic run, uniform distribution from 1/2 to twice the base value.	Uniform	0.05	0.2			
Density of bottom sediment	g/cm3	P	1.5	For deterministic run, base value selected is the code default. For probabilistic run, uniform distribution from +/-33 percent from base value	Uniform	1	2			
Thickness of bottom sediment layer in adsorption/desorption equilibrium of radionuclides with water	m	P	0.05	For deterministic run, base value selected is the code default. For probabilistic run, uniform distribution from 1/2 to twice the base value	Uniform	0.025	0.1			The radionuclides in the older sediment that is buried below the more recent sediment will not have the opportunity to be in equilibrium with the water in the surface water body. This is the thickness of the top layer of the sediment that is considered for the adsorption-desorption equilibrium of the radionuclide with that in the water
Sediment from primary contamination delivery ratio	—	P	1	For deterministic run, base value selected is the code default. For probabilistic run, uniform distribution from 1/2 to the base value	Uniform	0.5	1			The fraction of the contaminated soil that was eroded from the area of primary contamination that reaches the surface water body.
Number of catchment areas	—	P	1	Assumption	NR	NR	NR	NR	NR	Only one catchment area contributes to surface water body.
Catchment areas characteristics										
Smaller X-coordinate	m	P	-1450	Assumption	NR	NR	NR	NR		

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Table B-57 Base Values and Statistical Distributions of Input Parameters Used in the RESRAD-OFFSITE Code for Offsite Resident via Air Transport Scenario Analysis (cont.)

Input screen title/parameter	Units	Type[b]	Base value for deterministic calculation	Source	Probabilistic analysis[a]					Description
					Distribution	Parameter 1	Parameter 2	Parameter 3	Parameter 4	
Catchment areas characteristics (cont.)										
Larger X-coordinate	m	P	1550	Assumption	NR	NR	NR	NR		
Smaller Y-coordinate	m	P	-2450	Assumption	NR	NR	NR	NR		
Larger Y-coordinate	m	P	550	Assumption	NR	NR	NR	NR		
Surface area	m^2		9E6 (calculated from catchment area X and Y coordinates)							Calculated
Runoff coefficient	—	P	0.2	For deterministic run, base value selected is the code default. For probabilistic run, distribution from NUREG/CR-6697 is used.	Uniform	0.1	0.8			See primary contamination runoff coefficient.
Soil erodibility factor	Tons/acre	P	0.4	For deterministic run, base value selected is the code default. For probabilistic run, distribution from Yu et al. 2007 is used.	Continuous linear					See contaminated zone soil erodibility factor.
Slope-length-steepness factor	—	P	0.4	For deterministic run, base value selected is the code default. For probabilistic run, distribution from Yu et al. 2007 is used.	Continuous linear					See primary contamination slope-length-steepness factor
Cover and management factor	—	P	0.003	For deterministic run, base value selected is the code default. For probabilistic run, distribution from Yu et al. 2007 is used.	Continuous linear					See primary contamination cover and management factor

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[c] NR = not required.

Table B-57 Base Values and Statistical Distributions of Input Parameters Used in the RESRAD-OFFSITE Code for Offsite Resident via Air Transport Scenario Analysis (cont.)

Input screen title/parameter	Units	Type[b]	Base value for deterministic calculation	Source	Probabilistic analysis[a]					Description
					Distribution	Parameter 1	Parameter 2	Parameter 3	Parameter 4	
Catchment areas characteristics (cont.)										
Support practice factor	—	P	1	For deterministic run, base value selected is the code default. For probabilistic run, distribution from Yu et al. 2007 is used.	Continuous linear					See primary contamination slope-length-steepness factor
Sediment delivery ratio	—	P	0.21 (estimated using catchment area)							This is the fraction of the soil that was eroded from the catchment that reaches the surface water body
Fraction of deposited radionuclide reaching surface water body			0.02	For deterministic run, base value selected is the code default. For probabilistic run, uniform distribution from 1/2 to twice the base value.	Uniform	0.01	0.04			Fraction of deposited radionuclides reaching surface water body is modeled either by atmospheric deposition on catchment or approximated by atmospheric release
Model atmospheric deposition on catchment	—	P	Yes	Assumption	NR	NR	NR	NR	NR	The code has two option either model atmospheric deposition on catchment or approximate by atmospheric deposition
Approximate by atmospheric release	—	P	No	Assumption	NR	NR	NR	NR	NR	The code has two option either model atmospheric deposition on catchment or approximate by atmospheric deposition
Convergence criteria for atmospheric deposition			0.001	Assumption	NR	NR	NR	NR	NR	Conversion criteria for the areal integration of the atmospheric transport from the primary contamination to the catchment
Groundwater Transport ***Distance in the direction parallel to aquifer flow from downgradient edge of contamination to:***										
Well	m	P, B	100	For deterministic run, base value selected is the code default. For probabilistic run, uniform distribution from 1/2 to twice the base value.	Uniform	50	200			The distance between two parallel lines that are perpendicular to the direction of aquifer flow, one at the downgradient edge of the contaminated zone and the other at the well.

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[b] P = physical, B= behavioral, and M = metabolic parameter.
[c] NR = not required.

Table B-57 Base Values and Statistical Distributions of Input Parameters Used in the RESRAD-OFFSITE Code for Offsite Resident via Air Transport Scenario Analysis (cont.)

Input screen title/parameter	Units	Type[b]	Base value for deterministic calculation	Source	Probabilistic analysis[a]					Description
					Distribution	Parameter 1	Parameter 2	Parameter 3	Parameter 4	
Groundwater Transport (cont.) ***Distance in the direction parallel to aquifer flow from downgradient edge of contamination to:***										
Surface water body	m	P	450	For deterministic run, base value selected is the code default. For probabilistic run, uniform distribution from 1/2 to twice the base value.	Uniform	225	900			The distance between two parallel lines perpendicular to the direction of aquifer flow, one at the downgradient edge of the contaminated zone and the other at the closest point on the surface water body.
Distance in the direction perpendicular to aquifer flow from center of contamination to:										
Well	m	P, B	0	Assumption	NR	NR	NR	NR	NR	This the distance between two parallel lines that are parallel to the direction of aquifer flow, one through the center of the contaminated zone and the other at the well.
Left edge of surface water body	m	P	-150	Assumption	NR	NR	NR	NR	NR	This the distance between two parallel lines that are parallel to the direction of aquifer flow, one through the center of the contaminated zone and the other at the closest point on the surface water body.
Right edge of surface water body	m	P	150	Assumption	NR	NR	NR	NR	NR	This the distance between two parallel lines that are parallel to the direction of aquifer flow, one through the center of the contaminated zone and the other at the farthest point on the surface water body.
Convergence criterion (fractional accuracy desired)	—	P	0.001	Assumption	NR	NR	NR	NR	NR	It is the fractional accuracy desired (convergence criterion) in the Romberg integration used to calculate the contaminant flux or concentration in groundwater.
Number of subzones (to model dispersion of progeny produced in transit)										
Main subzones in contaminated medium	—	NA	NR	Assumption	NR	NR	NR	NR	NR	
Main subzones in primary contamination	—	NA	1	Assumption	NR	NR	NR	NR	NR	The primary contaminated zone divided into subzones to improve the predictions for the transport of progeny nuclides.
Main subzones in submerged primary contamination	—	NA	1	Assumption	NR	NR	NR	NR	NR	The submerged primary contamination zone divided into subzones to improve the predictions for the transport of progeny nuclides.

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[b] P = physical, B= behavioral, and M = metabolic parameter.

[c] NR = not required.

Table B-57 Base Values and Statistical Distributions of Input Parameters Used in the RESRAD-OFFSITE Code for Offsite Resident via Air Transport Scenario Analysis (cont.)

Input screen title/parameter	Units	Type[b]	Base value for deterministic calculation	Source	Probabilistic analysis[a]					Description
					Distribution	Parameter 1	Parameter 2	Parameter 3	Parameter 4	
Number of subzones (to model dispersion of progeny produced in transit) (cont.)										
Main subzones in saturated zone	—	NA	1	Assumption	NR	NR	NR	NR	NR	The saturated zone divided into subzones to improve the predictions for the transport of progeny nuclides.
Retardation and dispersion treatment										
Nuclide-specific retardation in all subzones, longitudinal dispersion in all but the subzone of transformation?	—	NA	Yes	Assumption	NR	NR	NR	NR	NR	When the layer is subdivided one must choose which process-- longitudinal dispersion or nuclide-specific retardation-- will be considered in the subzone in which each atom undergoes a transformation.
Longitudinal dispersion in all subzones, nuclide-specific retardation in all but the subzone of transformation, parent retardation in zone of transformation?	—	NA	No	Assumption	NR	NR	NR	NR	NR	See above.
Longitudinal dispersion in all subzones, nuclide-specific retardation in all but the subzone of transformation, progeny retardation in zone of transformation?	—	NA	No	Assumption	NR	NR	NR	NR	NR	See above.
Ingestion Rates										
Consumption Rate										
Drinking water intake	L/yr	M, B	510	Code default	None	NR	NR	NR	NR	The amount of water consumed by a single individual in a year.
Fish consumption	kg/yr	M, B	5.4	Code default	None	NR	NR	NR	NR	The weight of fish consumed by a single individual in a year.
Other aquatic food consumption	kg/yr	M, B	0.9	Code default	None	NR	NR	NR	NR	The weight of other aquatic organisms consumed by a single individual in a year.
Fruit, grain, non-leafy vegetables consumption	kg/yr	M, B	160	Code default	None	NR	NR	NR	NR	The weight of non-leafy vegetables, fruits, or grain consumed by a single individual in a year.

[a] For truncated lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution, parameter 3 = lower quantile, and parameter 4 = upper quantile; for lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution; for triangular distribution, parameter 1 = minimum, parameter 2 = mode or most likely, and parameter 3 = maximum; for truncated normal distribution, parameter 1 = mean, parameter 2 = standard deviation, parameter 3 = lower quantile, and parameter 4 = upper quantile; for bounded lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution, parameter 3 = minimum value, and parameter 4 = maximum value; for uniform distribution, parameter 1 = minimum, and parameter 2 = maximum; for continuous linear distribution, number of points, value of points, and CDF of points; for continuous logarithmic distribution, number of points, value of points, and CDF of points.

[b] P = physical, B= behavioral, and M = metabolic parameter.

[c] NR = not required.

Table B-57 Base Values and Statistical Distributions of Input Parameters Used in the RESRAD-OFFSITE Code for Offsite Resident via Air Transport Scenario Analysis (cont.)

Input screen title/parameter	Units	Type[b]	Base value for deterministic calculation	Source	Probabilistic analysis[a]					Description
					Distribution	Parameter 1	Parameter 2	Parameter 3	Parameter 4	
Consumption Rate (cont.)										
Leafy vegetables consumption	kg/yr	M, B	14	Code default	None	NR	NR	NR	NR	The weight of leafy vegetables consumed by a single individual in a year.
Meat consumption	kg/yr	M, B	63	Code default	None	NR	NR	NR	NR	The weight of meat consumed by a single individual in a year.
Milk consumption	L/yr	M, B	92	Code default	None	NR	NR	NR	NR	The weight of milk consumed by a single individual in a year.
Soil (incidental) ingestion rate	g/yr	M, B	36.5	Code default	None	NR	NR	NR	NR	The quantity of soil ingested by a single individual in a year.
Fraction from affected area										
Drinking water intake from affected area	—	B, P	1	Code default	None	NR	NR	NR	NR	The fraction of drinking water consumed by an individual obtained from the contaminated area.
Fish consumption from affected area	—	B, P	0.5	Code default	None	NR	NR	NR	NR	The fraction of fish consumed by an individual obtained from the contaminated surface water body.
Other aquatic food consumption from affected area	—	B, P	0.5	Code default	None	NR	NR	NR	NR	The fraction of the other aquatic food consumed by an individual obtained from the contaminated surface water body.
Fruit, grain, non-leafy vegetables consumption from affected area	—	B, P	0.5	Code default	None	NR	NR	NR	NR	The fraction of fruit, non-leafy vegetables, or grain consumed by an individual obtained from contaminated agricultural areas.
Leafy vegetables consumption from affected area	—	B, P	0.5	Code default	None	NR	NR	NR	NR	The fraction of leafy vegetables consumed by an individual obtained from contaminated agricultural areas.
Meat consumption from affected area	—	B, P	1	Code default	None	NR	NR	NR	NR	The fraction of meat consumed by an individual produced using contaminated feed and water.
Milk consumption from affected area	—	B, P	1	Code default	None	NR	NR	NR	NR	The fraction of milk consumed by an individual produced using contaminated feed and water.
Livestock Intakes										
Water intake for meat cows	L/d	M	50	Code default	None	NR	NR	NR	NR	The daily intake of water by meat cows kept for meat production.
Pasture and silage intake for meat cows	kg/d	M	14	Code default	None	NR	NR	NR	NR	The daily intake of silage or pasture by meat cows kept for meat production.

[a] For truncated lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution, parameter 3 = lower quantile, and parameter 4 = upper quantile; for lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution; for triangular distribution, parameter 1 = minimum, parameter 2 = mode or most likely, and parameter 3 = maximum; for truncated normal distribution, parameter 1 = mean, parameter 2 = standard deviation, parameter 3 = lower quantile, and parameter 4 = upper quantile; for bounded lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution, parameter 3 = minimum value, and parameter 4 = maximum value; for uniform distribution, parameter 1 = minimum, and parameter 2 = maximum; for continuous linear distribution, number of points, value of points, and CDF of points; for continuous logarithmic distribution, number of points, value of points, and CDF of points.

[b] P = physical, B= behavioral, and M = metabolic parameter.

[c] NR = not required.

Table B-57 Base Values and Statistical Distributions of Input Parameters Used in the RESRAD-OFFSITE Code for Offsite Resident via Air Transport Scenario Analysis (cont.)

Input screen title/parameter	Units	Type[b]	Base value for deterministic calculation	Source	Probabilistic analysis[a]					Description
					Distribution	Parameter 1	Parameter 2	Parameter 3	Parameter 4	
Livestock Intakes										
Grain intake for meat cows	kg/d	M	54	Code default	None	NR	NR	NR	NR	The daily intake of grain by meat cows kept for meat production.
Soil from pasture and silage intake for meat cows	kg/d	M	0.1	Code default	None	NR	NR	NR	NR	The daily incidental intake of soil with silage or pasture by meat cows kept for meat production.
Soil from grain intake for meat cows	kg/d	M	0.4	Code default	None	NR	NR	NR	NR	The daily incidental intake of soil with grain by meat cows kept for meat production.
Water intake for milk cows	L/d	M	160	Code default	None	NR	NR	NR	NR	The daily intake of water by milk cows kept for milk production.
Pasture and silage intake for milk cows	kg/d	M	44	Code default	None	NR	NR	NR	NR	The daily intake of silage or pasture by milk cows kept for milk production.
Grain intake for milk cows	kg/d	M	11	Code default	None	NR	NR	NR	NR	The daily intake of grain by milk cows kept for milk production.
Soil from pasture and silage intake for milk cows	kg/d	M	0.4	Code default	None	NR	NR	NR	NR	The daily incidental intake of soil with silage or pasture by milk cows kept for milk production.
Soil from grain intake for milk cows	kg/d	M	0.1	Code default	None	NR	NR	NR	NR	The daily incidental intake of soil with grain by milk cows kept for milk production.
Livestock Feed Factors										
Wet weight crop yield of pasture and silage	kg/m^2	P	1.1	Code default	None	NR	NR	NR	NR	The mass (wet weight) of the edible portion of pasture and silage consumed by livestock produced from a unit land area.
Duration of growing season of pasture and silage	yr	P	0.08	Code default	None	NR	NR	NR	NR	The time duration during which the pasture and silage consumed by livestock is exposed to contamination by foliar deposition and root uptake.
Foliage to food transfer coefficient of pasture and silage	—	P	1	Code default	None	NR	NR	NR	NR	The contaminant foliage-to-food transfer coefficient. A fraction of the contaminants that retains on foliage of the pasture and silage that will be absorbed and transferred to the edible portion of the pasture and silage consumed by livestock.

[a] For truncated lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution, parameter 3 = lower quantile, and parameter 4 = upper quantile; for lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution; for triangular distribution, parameter 1 = minimum, parameter 2 = mode or most likely, and parameter 3 = maximum; for truncated normal distribution, parameter 1 = mean, parameter 2 = standard deviation, parameter 3 = lower quantile, and parameter 4 = upper quantile; for bounded lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution, parameter 3 = minimum value, and parameter 4 = maximum value; for uniform distribution, parameter 1 = minimum, and parameter 2 = maximum; for continuous linear distribution, number of points, value of points, and CDF of points; for continuous logarithmic distribution, number of points, value of points, and CDF of points.

[b] P = physical, B= behavioral, and M = metabolic parameter.

[c] NR = not required.

Table B-57 Base Values and Statistical Distributions of Input Parameters Used in the RESRAD-OFFSITE Code for Offsite Resident via Air Transport Scenario Analysis (cont.)

Input screen title/parameter	Units	Type[b]	Base value for deterministic calculation	Source	Probabilistic analysis[a]					Description
					Distribution	Parameter 1	Parameter 2	Parameter 3	Parameter 4	
Livestock Feed Factors (cont.)										
Weathering removal constant of pasture and silage	1/yr	P	20	Code default	None	NR	NR	NR	NR	The weathering process would remove contaminants from foliage of the pasture and silage consumed by livestock. The process is characterized by a removal constant and it reduces the amount of contaminants on foliage exponentially during the exposure period.
Foliar interception factor for irrigation of pasture and silage	—	P	0.25	Code default	None	NR	NR	NR	NR	The fraction of deposited radionuclides from irrigation that retains on the foliage of the pasture and silage food consumed by livestock.
Foliar interception factor for dust of pasture and silage	—	P	0.25	Code default	None	NR	NR	NR	NR	The fraction of deposited radionuclides from mass loading that retains on the foliage of the pasture and silage food consumed by livestock.
Root depth of pasture and silage	m	P	0.9	Code default	None	NR	NR	NR	NR	The maximum root depth of the pasture and silage consumed by livestock.
Wet weight crop yield of grain	kg/m^2	P	0.7	Code default	None	NR	NR	NR	NR	The mass (wet weight) of the edible portion of grain consumed by livestock produced from a unit land area.
Duration of growing season of grain	yr	P	0.17	Code default	None	NR	NR	NR	NR	The period of time during which the grain consumed by livestock exposed to contamination by foliar deposition and root uptake.
Foliage to food transfer coefficient of grain	—	P	0.1	Code default	None	NR	NR	NR	NR	The contaminant foliage-to-food transfer coefficient. A fraction of the contaminants that retain on foliage of the grain consumed by livestock will be absorbed and transferred to the edible portion of the grain.
Weathering removal constant of grain	1/yr	P	20	Code default	None	NR	NR	NR	NR	The weathering process would remove contaminants from foliage of the grain consumed by livestock. The process characterized by a removal constant and reduces the amount of contaminants on foliage exponentially during the exposure period.
Foliar interception factor for irrigation of grain	—	P	0.25	Code default	None	NR	NR	NR	NR	The fraction of deposited radionuclides from irrigation that retains on the foliage of the grain consumed by livestock.

[a] For truncated lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution, parameter 3 = lower quantile, and parameter 4 = upper quantile; for lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution; for triangular distribution, parameter 1 = minimum, parameter 2 = mode or most likely, and parameter 3 = maximum; for truncated normal distribution, parameter 1 = mean, parameter 2 = standard deviation, parameter 3 = lower quantile, and parameter 4 = upper quantile; for bounded lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution, parameter 3 = minimum value, and parameter 4 = maximum value; for uniform distribution, parameter 1 = minimum, and parameter 2 = maximum; for continuous linear distribution, number of points, value of points, and CDF of points; for continuous logarithmic distribution, number of points, value of points, and CDF of points.

[b] P = physical, B= behavioral, and M = metabolic parameter.

[c] NR = not required.

Table B-57 Base Values and Statistical Distributions of Input Parameters Used in the RESRAD-OFFSITE Code for Offsite Resident via Air Transport Scenario Analysis (cont.)

Input screen title/parameter	Units	Type[b]	Base value for deterministic calculation	Source	Probabilistic analysis[a]					Description
					Distribution	Parameter 1	Parameter 2	Parameter 3	Parameter 4	
Livestock Feed Factors (cont.)										
Foliar interception factor for dust of grain	—	P	0.25	Code default	None	NR	NR	NR	NR	The fraction of deposited radionuclides from mass loading that retains on the foliage of the grain consumed by livestock.
Root depth of grain	m	P	1.2	Code default	None	NR	NR	NR	NR	The maximum root depth of the grain consumed by livestock.
Plant Factors										
Wet weight crop yield of fruit, grain, and non-leafy vegetables	kg/m^2	P	0.7	Code default	None	NR	NR	NR	NR	The mass (wet weight) of the edible portion of fruit, grain, and non-leafy vegetables produced from a unit land area.
Duration of growing season of fruit, grain, and non-leafy vegetables	yr	P	0.17	Code default	None	NR	NR	NR	NR	The period of time during which the fruit, grain, and leafy vegetables exposed to contamination by foliar deposition and root uptake.
Foliage to food transfer coefficient of fruit, grain, and non-leafy vegetables	—	P	0.1	Code default	None	NR	NR	NR	NR	The contaminant foliage-to-food transfer coefficient. A fraction of the contaminants that retain on foliage of the fruit, grain, and non-leafy vegetables will be absorbed and transferred to the edible portion of the pasture and silage.
Weathering removal constant of fruit, grain, and non-leafy vegetables	1/yr	P	20	Code default	None	NR	NR	NR	NR	The weathering process would remove contaminants from foliage of the fruit, grain, and non-leafy vegetables. The process characterized by a removal constant and reduces the amount of contaminants on foliage exponentially during the exposure period.
Foliar interception factor for irrigation of fruit, grain, and non-leafy vegetables	—	P	0.25	Code default	None	NR	NR	NR	NR	The fraction of deposited radionuclides from irrigation that is retained on the foliage of the fruit, grain, and non-leafy vegetables.
Foliar interception factor for dust of fruit, grain, and non-leafy vegetables	—	P	0.25	Code default	None	NR	NR	NR	NR	The fraction of deposited radionuclides from mass loading that is retained on the foliage of the fruit, grain, and non-leafy vegetables.
Root depth of fruit, grain, and non-leafy vegetables	m	P	1.2	Code default	None	NR	NR	NR	NR	The maximum root depth of the fruit, grain, and non-leafy vegetables.
Wet weight crop yield of leafy vegetables	kg/m^2	P	1.5	Code default	None	NR	NR	NR	NR	The mass (wet weight) of the edible portion of leafy vegetables produced from a unit land area.

[a] For truncated lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution, parameter 3 = lower quantile, and parameter 4 = upper quantile; for lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution; for triangular distribution, parameter 1 = minimum, parameter 2 = mode or most likely, and parameter 3 = maximum; for truncated normal distribution, parameter 1 = mean, parameter 2 = standard deviation, parameter 3 = lower quantile, and parameter 4 = upper quantile; for bounded lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution, parameter 3 = minimum value, and parameter 4 = maximum value; for uniform distribution, parameter 1 = minimum, and parameter 2 = maximum; for continuous linear distribution, number of points, value of points, and CDF of points; for continuous logarithmic distribution, number of points, value of points, and CDF of points.

[b] P = physical, B= behavioral, and M = metabolic parameter.

[c] NR = not required.

Table B-57 Base Values and Statistical Distributions of Input Parameters Used in the RESRAD-OFFSITE Code for Offsite Resident via Air Transport Scenario Analysis (cont.)

Input screen title/parameter	Units	Type[b]	Base value for deterministic calculation	Source	Probabilistic analysis[a]					Description
					Distribution	Parameter 1	Parameter 2	Parameter 3	Parameter 4	
Plant Factors (cont.)										
Duration of growing season of leafy vegetables	yr	P	0.25	Code default	None	NR	NR	NR	NR	The period of time during which the leafy vegetables exposed to contamination by foliar deposition and root uptake.
Foliage to food transfer coefficient of leafy vegetables	—	P	1	Code default	None	NR	NR	NR	NR	The contaminant foliage-to-food transfer coefficient. A fraction of the contaminants that retain on foliage of the leafy vegetables will be absorbed and transferred to the edible portion of the pasture and silage.
Weathering removal constant of leafy vegetables	1/yr	P	20	Code default	None	NR	NR	NR	NR	The weathering process would remove contaminants from foliage of the leafy vegetables. The process characterized by a removal constant and reduces the amount of contaminants on foliage exponentially during the exposure period.
Foliar interception factor for irrigation of leafy vegetables	—	P	0.25	Code default	None	NR	NR	NR	NR	The fraction of deposited radionuclides from irrigation that retains on the foliage of the leafy vegetables.
Foliar interception factor for dust of leafy vegetables	—	P	0.25	Code default	None	NR	NR	NR	NR	The fraction of deposited radionuclides from mass loading that retains on the foliage of the leafy vegetables.
Root depth of leafy vegetables	m	P	0.9	Code default	None	NR	NR	NR	NR	The maximum root depth of the leafy vegetables.
Inhalation and External Gamma										
Inhalation rate	m^3/yr	M, B	8400	Code default	NR	NR	NR	NR	NR	The annual air intake.
Mass loading of all particulates from primary contamination	g/m^3	P, B	0.0001	For deterministic run, base value selected is the code default. For probabilistic run, distribution from Yu et al. 2007 is used.	Lognormal	-10.02	0.455	0.001	0.999	The mass loading of airborne contaminated soil particles from primary contamination.
Respirable particulates as a fraction of total particulates			1	Code default	NR	NR	NR	NR	NR	
Mass loading and respirable fraction at offsite locations		P, B	Use same value as for primary contamination							The user has an option to input mass loading and respirable fractions at all offsite locations or use the same values as for primary contamination.

[a] For truncated lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution, parameter 3 = lower quantile, and parameter 4 = upper quantile; for lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution; for triangular distribution, parameter 1 = minimum, parameter 2 = mode or most likely, and parameter 3 = maximum; for truncated normal distribution, parameter 1 = mean, parameter 2 = standard deviation, parameter 3 = lower quantile, and parameter 4 = upper quantile; for bounded lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution, parameter 3 = minimum value, and parameter 4 = maximum value; for uniform distribution, parameter 1 = minimum, and parameter 2 = maximum; for continuous linear distribution, number of points, value of points, and CDF of points; for continuous logarithmic distribution, number of points, value of points, and CDF of points.

[b] P = physical, B= behavioral, and M = metabolic parameter.

[c] NR = not required.

Table B-57 Base Values and Statistical Distributions of Input Parameters Used in the RESRAD-OFFSITE Code for Offsite Resident via Air Transport Scenario Analysis (cont.)

Input screen title/parameter	Units	Type[b]	Base value for deterministic calculation	Source	Probabilistic analysis[a]					Description
					Distribution	Parameter 1	Parameter 2	Parameter 3	Parameter 4	
Inhalation and External Gamma (cont.)										
Indoor to outdoor dust concentration ratio	—	P, B	0.4	For deterministic run, base value selected is the code default. For probabilistic run, distribution from NUREG/CR-6697 is used.	Uniform	0.15	0.95			The indoor to outdoor dust concentration ratio describes the effect of the building structure on the level of contaminated dust existing indoors. Specifically, the factor is the fraction of outdoor contaminated dust that will be available indoors.
External gamma penetration factor	—	P	0.7	For deterministic run, base value selected is the code default. For probabilistic run, distribution from NUREG/CR-6697 is used.	Bounded Lognormal-N	-1.3	0.59	0.044	1	The penetration factor describes the effect of the building structure on the level of gamma radiation existing indoors. Specifically, the penetration factor is the fraction of outdoor gamma radiation that will be available indoors.
External Radiation Shape and Area Factors										
Shape of the onsite contamination (shape factor flag)	—	P	Circular	Code default	None	NR	NR	NR	NR	The code has the capability to handle any shape of contaminated area, if the shape factor flag is set. The shape factor data is calculated by drawing 12 concentric circles emanating from the receptor location inside (or possibly outside) the contaminated area. The outermost circle circumscribes the entire contaminated zone. For the innermost circle, the radius is 1/12 of the radius of the outermost circle. For each of the annular rings beyond the innermost circle, the distance between inner and outer radii is 1/12 of the radius of the outermost circle. The code then estimates the fraction of each annular ring within the contaminated zone displayed in the graphic.
Shape of the offsite contamination (shape factor flag)	—	P	Circular	Parameter not required	NR	NR	NR	NR	NR	Same as above.

[a] For truncated lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution, parameter 3 = lower quantile, and parameter 4 = upper quantile; for lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution; for triangular distribution, parameter 1 = minimum, parameter 2 = mode or most likely, and parameter 3 = maximum; for truncated normal distribution, parameter 1 = mean, parameter 2 = standard deviation, parameter 3 = lower quantile, and parameter 4 = upper quantile; for bounded lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution, parameter 3 = minimum value, and parameter 4 = maximum value; for uniform distribution, parameter 1 = minimum, and parameter 2 = maximum; for continuous linear distribution, number of points, value of points, and CDF of points; for continuous logarithmic distribution, number of points, value of points, and CDF of points.

[b] P = physical, B= behavioral, and M = metabolic parameter.

[c] NR = not required.

Table B-57 Base Values and Statistical Distributions of Input Parameters Used in the RESRAD-OFFSITE Code for Offsite Resident via Air Transport Scenario Analysis (cont.)

Input screen title/parameter	Units	Type[b]	Base value for deterministic calculation	Source	Probabilistic analysis[a]					Description
					Distribution	Parameter 1	Parameter 2	Parameter 3	Parameter 4	
Occupancy										
Indoor time fraction on primary contamination	—	B	0	Code default	None	NR	NR	NR	NR	The average fraction of time during which an individual stays inside a house built on top of the primary contamination.
Outdoor time fraction on primary contamination	—	B	0	Code default	None	NR	NR	NR	NR	The average fraction of a day during which an individual stays outdoors on the area of primary contamination
Indoor time fraction offsite, at offsite dwelling	—	B	0.5	Code default	None	NR	NR	NR	NR	The average fraction of time during which an individual stays inside a house at offsite dwelling location.
Outdoor time fraction at outside dwelling.	—	B	0.1	Code default	None	NR	NR	NR	NR	The average fraction of a day during which an individual stays outdoors outside at offsite dwelling.
Time fraction in fruit, grain, and non-leafy vegetable fields	—	B	0.1	Code default	None	NR	NR	NR	NR	The average fraction of a day during which an individual stays outside in fruit, grain, and non-leafy vegetable fields.
Time fraction in leafy vegetable fields	—	B	0.1	Code default	None	NR	NR	NR	NR	The average fraction of a day during which an individual stays outside in leafy vegetable fields.
Time fraction in pasture and silage fields	—	B	0.1	Code default	None	NR	NR	NR	NR	The average fraction of a day during which an individual stays outside in pasture and silage field.
Time fraction in livestock grain fields	—	B	0.1	Code default	None	NR	NR	NR	NR	The average fraction of a day during which an individual stays outside in livestock grain field.

[a] For truncated lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution, parameter 3 = lower quantile, and parameter 4 = upper quantile; for lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution; for triangular distribution, parameter 1 = minimum, parameter 2 = mode or most likely, and parameter 3 = maximum; for truncated normal distribution, parameter 1 = mean, parameter 2 = standard deviation, parameter 3 = lower quantile, and parameter 4 = upper quantile; for bounded lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution, parameter 3 = minimum value, and parameter 4 = maximum value; for uniform distribution, parameter 1 = minimum, and parameter 2 = maximum; for continuous linear distribution, number of points, value of points, and CDF of points; for continuous logarithmic distribution, number of points, value of points, and CDF of points.

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[c] NR = not required.

Table B-57 Base Values and Statistical Distributions of Input Parameters Used in the RESRAD-OFFSITE Code for Offsite Resident via Air Transport Scenario Analysis (cont.)

Input screen title/parameter	Units	Type[b]	Base value for deterministic calculation	Source	Probabilistic analysis[a]					Description
					Distribution	Parameter 1	Parameter 2	Parameter 3	Parameter 4	
Radon										
Effective radon diffusion coefficient of cover	m^2/s	P	2E-6	The value used in the deterministic run is the code default. The parameter has triangular distribution with the default as the mode in the distribution and the minimum value of the distribution is 1/10 of the default value, and the maximum value of the distribution is the maximum for uranium mill tailings from data collection handbook Table 4.1.1.	Triangular	2.00E-07	2.00E-06	7.00E-06	NR	The effective (or interstitial) radon diffusion coefficient is the ratio of the gradient of the radon activity concentration in the pore space to the diffusive flux density of radon activity across the pore area. Entering –1 for any diffusion coefficient will cause the code to calculate a diffusion coefficient based on the porosity and water content of the medium.
Effective radon diffusion coefficient of contaminated zone	m^2/s	P	2E-6	The value used in the deterministic run is the code default. The parameter has triangular distribution with the default as the mode in the distribution and the minimum value of the distribution is 1/10 of the default value, and the maximum value of the distribution is the maximum for uranium mill tailings from data collection handbook Table 4.1.1.	Triangular	2.00E-07	2.00E-06	7.00E-06	NR	Same as above.

[a] For truncated lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution, parameter 3 = lower quantile, and parameter 4 = upper quantile; for lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution; for triangular distribution, parameter 1 = minimum, parameter 2 = mode or most likely, and parameter 3 = maximum; for truncated normal distribution, parameter 1 = mean, parameter 2 = standard deviation, parameter 3 = lower quantile, and parameter 4 = upper quantile; for bounded lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution, parameter 3 = minimum value, and parameter 4 = maximum value; for uniform distribution, parameter 1 = minimum, and parameter 2 = maximum; for continuous linear distribution, number of points, value of points, and CDF of points; for continuous logarithmic distribution, number of points, value of points, and CDF of points.

[b] P = physical, B= behavioral, and M = metabolic parameter.

[c] NR = not required.

Table B-57 Base Values and Statistical Distributions of Input Parameters Used in the RESRAD-OFFSITE Code for Offsite Resident via Air Transport Scenario Analysis (cont.)

Input screen title/parameter	Units	Type[b]	Base value for deterministic calculation	Source	Probabilistic analysis[a]					Description
					Distribution	Parameter 1	Parameter 2	Parameter 3	Parameter 4	
Radon (cont.)										
Effective radon diffusion coefficient of floor	m^2/s	P	3E-7	The value used in the deterministic run is the code default. The parameter has triangular distribution with the default as the mode in the distribution and the minimum value of the distribution is 1/10 of the default, and the maximum value of the distribution is the maximum for concrete from data collection handbook Table 4.1.1.	Triangular	3.00E-08	3.00E-07	5.00E-07	NR	Same as above.
Thickness of floor and foundation	m	P	0.15	The value used in the deterministic run is the code default. The parameter has triangular distribution with the default as the mode in the distribution and the minimum value of the distribution is 1/2 of the default value, and the maximum value of the distribution is twice the default value.	Triangular	7.50E-02	1.50E-01	3.00E-01	NR	The building foundation thickness is the average thickness of the building shell structure in the subsurface of the soil.

[a] For truncated lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution, parameter 3 = lower quantile, and parameter 4 = upper quantile; for lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution; for triangular distribution, parameter 1 = minimum, parameter 2 = mode or most likely, and parameter 3 = maximum; for truncated normal distribution, parameter 1 = mean, parameter 2 = standard deviation, parameter 3 = lower quantile, and parameter 4 = upper quantile; for bounded lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution, parameter 3 = minimum value, and parameter 4 = maximum value; for uniform distribution, parameter 1 = minimum, and parameter 2 = maximum; for continuous linear distribution, number of points, value of points, and CDF of points; for continuous logarithmic distribution, number of points, value of points, and CDF of points.

[b] P = physical, B= behavioral, and M = metabolic parameter.

[c] NR = not required.

Table B-57 Base Values and Statistical Distributions of Input Parameters Used in the RESRAD-OFFSITE Code for Offsite Resident via Air Transport Scenario Analysis (cont.)

Input screen title/parameter	Units	Type[b]	Base value for deterministic calculation	Source	Probabilistic analysis[a]					Description
					Distribution	Parameter 1	Parameter 2	Parameter 3	Parameter 4	
Radon (cont.)										
Density of floor and foundation	g/cm^3	P	2.4	The value used in the deterministic run is the code default. For probabilistic analysis, distribution from NUREG/CR-6755 is used.	Triangular	2.20E+00	2.40E+00	2.60E+00	NR	The building-foundation bulk density is the ratio of the solid-phase mass to the total volume.
Total porosity of floor and foundation	—	P	0.1	The value used in the deterministic run is the code default. The parameter has triangular distribution with the default as the mode in the distribution and the minimum value of the distribution is the minimum and the maximum value of the distribution is the maximum porosity for concrete (NUREG/CR-6755).	Triangular	4.00E-02	1.00E-01	2.50E-01	NR	Total porosity is the ratio of the void-space volume to the total volume of a porous medium.

[a] For truncated lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution, parameter 3 = lower quantile, and parameter 4 = upper quantile; for lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution; for triangular distribution, parameter 1 = minimum, parameter 2 = mode or most likely, and parameter 3 = maximum; for truncated normal distribution, parameter 1 = mean, parameter 2 = standard deviation, parameter 3 = lower quantile, and parameter 4 = upper quantile; for bounded lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution, parameter 3 = minimum value, and parameter 4 = maximum value; for uniform distribution, parameter 1 = minimum, and parameter 2 = maximum; for continuous linear distribution, number of points, value of points, and CDF of points; for continuous logarithmic distribution, number of points, value of points, and CDF of points.

[b] P = physical, B= behavioral, and M = metabolic parameter.

[c] NR = not required.

Table B-57 Base Values and Statistical Distributions of Input Parameters Used in the RESRAD-OFFSITE Code for Offsite Resident via Air Transport Scenario Analysis (cont.)

Input screen title/parameter	Units	Type[b]	Base value for deterministic calculation	Source	Probabilistic analysis[a]					Description
					Distribution	Parameter 1	Parameter 2	Parameter 3	Parameter 4	
Radon (cont.)										
Volumetric water content of floor and foundation	—	P	0.03	The value used in the deterministic run is the code default. The parameter has triangular distribution with the default as the mode in the distribution and the minimum value of the distribution is 1/2 of the default value, and the maximum value of the distribution is twice the default value.	Triangular	1.50E-02	3.00E-02	6.00E-02	NR	The volumetric water content in a porous medium represents the fraction of the total volume of porous medium occupied by the water contained in the porous medium. The value should be less than the total porosity of the porous medium.
Depth of foundation below ground level	m	P	-1	Code default	None	NR	NR	NR	NR	The foundation depth below ground surface is the vertical distance in the soil immediately from the bottom of the basement floor slab to the ground surface. For a negative value, the absolute value will be adjusted (if needed) so the foundation depth will not extend into the contaminated zone. Thus, due to erosion of the cover and contaminated zones, the foundation depth could be time-dependent and less than the (absolute) specified value.

[a] For truncated lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution, parameter 3 = lower quantile, and parameter 4 = upper quantile; for lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution; for triangular distribution, parameter 1 = minimum, parameter 2 = mode or most likely, and parameter 3 = maximum; for truncated normal distribution, parameter 1 = mean, parameter 2 = standard deviation, parameter 3 = lower quantile, and parameter 4 = upper quantile; for bounded lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution, parameter 3 = minimum value, and parameter 4 = maximum value; for uniform distribution, parameter 1 = minimum, and parameter 2 = maximum; for continuous linear distribution, number of points, value of points, and CDF of points; for continuous logarithmic distribution, number of points, value of points, and CDF of points.

[b] P = physical, B= behavioral, and M = metabolic parameter.

[c] NR = not required.

Table B-57 Base Values and Statistical Distributions of Input Parameters Used in the RESRAD-OFFSITE Code for Offsite Resident via Air Transport Scenario Analysis (cont.)

Input screen title/parameter	Units	Type[b]	Base value for deterministic calculation	Source	Probabilistic analysis[a]					Description
					Distribution	Parameter 1	Parameter 2	Parameter 3	Parameter 4	
Radon (cont.)										
Radon vertical dimension of mixing	m	P	2	The value used in the deterministic run is code default. The parameter has triangular distribution with the default as the mode in the distribution and the minimum value of the distribution is 1/2 of the default value, and the maximum value of the distribution is twice the default value.	Triangular	1.00E+00	2.00E+00	4.00E+00	NR	Radon vertical dimension of mixing is the height into which the plume of radon is uniformly mixed in the outdoor air.
Building room height	m	P	2.5	For deterministic run, base value selected is the code default. For probabilistic run, distribution from NUREG/CR-6755 is used.	Triangular	2.40E+00	3.70E+00	9.10E+00	NR	The building room height is the average height of the rooms in the building.
Building air exchange rate	1/hr	B	0.5	For deterministic run, base value selected is the code default. For probabilistic run, distribution from NUREG/CR-6755 is used.	Truncated Lognormal-n	4.19E-01	8.80E-01	1.00E-03	9.99E-01	The building air exchange (or ventilation) rate is the number of the total volumes of air contained in the building exchanged with outside air per unit of time.
Building indoor area factor	—	P	0	Code default	None	NR	NR	NR	NR	The building indoor area factor is the fraction of the floor area built on the contaminated area.Values greater than 1.0 indicate a contribution from walls extending into the contaminated zone.A default value of 0.0 means the code will calculate automatically a time-dependent area factor for floor area of 100 m^2 and the amount of wall area extending into the contaminated zone.

[a] For truncated lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution, parameter 3 = lower quantile, and parameter 4 = upper quantile; for lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution; for triangular distribution, parameter 1 = minimum, parameter 2 = mode or most likely, and parameter 3 = maximum; for truncated normal distribution, parameter 1 = mean, parameter 2 = standard deviation, parameter 3 = lower quantile, and parameter 4 = upper quantile; for bounded lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution, parameter 3 = minimum value, and parameter 4 = maximum value; for uniform distribution, parameter 1 = minimum, and parameter 2 = maximum; for continuous linear distribution, number of points, value of points, and CDF of points; for continuous logarithmic distribution, number of points, value of points, and CDF of points.

[b] P = physical, B= behavioral, and M = metabolic parameter.

[c] NR = not required.

Table B-57 Base Values and Statistical Distributions of Input Parameters Used in the RESRAD-OFFSITE Code for Offsite Resident via Air Transport Scenario Analysis (cont.)

Input screen title/parameter	Units	Type[b]	Base value for deterministic calculation	Source	Probabilistic analysis[a]					Description
					Distribution	Parameter 1	Parameter 2	Parameter 3	Parameter 4	
Radon (cont.)										
Rn-222 emanation coefficient	—	P	0.25	The value used in the deterministic run is the code default. The parameter has triangular distribution with the default as the mode in the distribution and the minimum value of the distribution and maximum value of the distribution are from Table 4.2.5 of the data collection handbook for different type of soil in the United States.	Triangular	2.00E-02	2.50E-01	7.00E-01	NR	The radon emanation coefficient for Rn-222 is the fraction of the total Rn-222 generated by radium decay that escapes from the soil particles. The emanating power is dependent upon on many factors, such as mineralogy, porosity, particle size distribution, and moisture content.
Rn-220 emanation coefficient	—	P	0.15	The value used in the deterministic run is the code default. The parameter has triangular distribution with the default as the mode in the distribution and the minimum value of the distribution and maximum value of the distribution are mean -1 SD and mean +1 SD, respectively, of the soil value listed in Table 4.2.1 of the data collection handbook.	Triangular	9.00E-02	1.50E-01	2.20E-01	NR	The radon emanation coefficient for Rn-220 is the fraction of the total Rn-220 generated by radium decay that escapes from the soil particles. The emanating power is dependent upon on many factors, such as mineralogy, porosity, particle size distribution, and moisture content.

[a] For truncated lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution, parameter 3 = lower quantile, and parameter 4 = upper quantile; for lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution; for triangular distribution, parameter 1 = minimum, parameter 2 = mode or most likely, and parameter 3 = maximum; for truncated normal distribution, parameter 1 = mean, parameter 2 = standard deviation, parameter 3 = lower quantile, and parameter 4 = upper quantile; for bounded lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution, parameter 3 = minimum value, and parameter 4 = maximum value; for uniform distribution, parameter 1 = minimum, and parameter 2 = maximum; for continuous linear distribution, number of points, value of points, and CDF of points; for continuous logarithmic distribution, number of points, value of points, and CDF of points.

[b] P = physical, B= behavioral, and M = metabolic parameter.

[c] NR = not required.

Table B-57 Base Values and Statistical Distributions of Input Parameters Used in the RESRAD-OFFSITE Code for Offsite Resident via Air Transport Scenario Analysis (cont.)

Input screen title/parameter	Units	Type[b]	Base value for deterministic calculation	Source	Probabilistic analysis[a]					Description
					Distribution	Parameter 1	Parameter 2	Parameter 3	Parameter 4	
Radon (cont.)										
Effective radon diffusion coefficient of non-leafy vegetable field	m^2/s	P	2E-6	The value used in the deterministic run is the code default. The parameter has triangular distribution with the default as the mode in the distribution and the minimum value of the distribution is 1/10 of the default value, and the maximum value of the distribution is the maximum for uranium mill tailings from data collection handbook Table 4.1.1.	Triangular	2.00E-07	2.00E-06	7.00E-06	NR	See cover effective diffusion coefficient
Effective radon diffusion coefficient of leafy vegetable field	m^2/s	P	2E-6	The value used in the deterministic run is the code default. The parameter has triangular distribution with the default as the mode in the distribution and the minimum value of the distribution is 1/10 of the default value, and the maximum value of the distribution is the maximum for uranium mill tailings from data collection handbook Table 4.1.1.	Triangular	2.00E-07	2.00E-06	7.00E-06	NR	See cover effective diffusion coefficient

a For truncated lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution, parameter 3 = lower quantile, and parameter 4 = upper quantile; for lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution; for triangular distribution, parameter 1 = minimum, parameter 2 = mode or most likely, and parameter 3 = maximum; for truncated normal distribution, parameter 1 = mean, parameter 2 = standard deviation, parameter 3 = lower quantile, and parameter 4 = upper quantile; for bounded lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution, parameter 3 = minimum value, and parameter 4 = maximum value; for uniform distribution, parameter 1 = minimum, and parameter 2 = maximum; for continuous linear distribution, number of points, value of points, and CDF of points; for continuous logarithmic distribution, number of points, value of points, and CDF of points.

b P = physical, B= behavioral, and M = metabolic parameter.

c NR = not required.

Table B-57 Base Values and Statistical Distributions of Input Parameters Used in the RESRAD-OFFSITE Code for Offsite Resident via Air Transport Scenario Analysis (cont.)

Input screen title/parameter	Units	Type[b]	Base value for deterministic calculation	Source	Probabilistic analysis[a]					Description
					Distribution	Parameter 1	Parameter 2	Parameter 3	Parameter 4	
Radon (cont.)										
Effective radon diffusion coefficient of pasture and silage field	m^2/s	P	2E-6	The value used in the deterministic run is the code default. The parameter has triangular distribution with the default as the mode in the distribution and the minimum value of the distribution is 1/10 of the default value, and the maximum value of the distribution is the maximum for uranium mill tailings from data collection handbook Table 4.1.1.	Triangular	2.00E-07	2.00E-06	7.00E-06	NR	See cover effective diffusion coefficient
Effective radon diffusion coefficient of livestock grain field	m^2/s	P	2E-6	The value used in the deterministic run is the code default. The parameter has triangular distribution with the default as the mode in the distribution and the minimum value of the distribution is 1/10 of the default value, and the maximum value of the distribution is the maximum for uranium mill tailings from data collection handbook Table 4.1.1.	Triangular	2.00E-07	2.00E-06	7.00E-06	NR	See cover effective diffusion coefficient

[a] For truncated lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution, parameter 3 = lower quantile, and parameter 4 = upper quantile; for lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution; for triangular distribution, parameter 1 = minimum, parameter 2 = mode or most likely, and parameter 3 = maximum; for truncated normal distribution, parameter 1 = mean, parameter 2 = standard deviation, parameter 3 = lower quantile, and parameter 4 = upper quantile; for bounded lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution, parameter 3 = minimum value, and parameter 4 = maximum value; for uniform distribution, parameter 1 = minimum, and parameter 2 = maximum; for continuous linear distribution, number of points, value of points, and CDF of points; for continuous logarithmic distribution, number of points, value of points, and CDF of points.

[b] P = physical, B= behavioral, and M = metabolic parameter.

[c] NR = not required.

Table B-57 Base Values and Statistical Distributions of Input Parameters Used in the RESRAD-OFFSITE Code for Offsite Resident via Air Transport Scenario Analysis (cont.)

Input screen title/parameter	Units	Type[b]	Base value for deterministic calculation	Source	Probabilistic analysis[a]					Description
					Distribution	Parameter 1	Parameter 2	Parameter 3	Parameter 4	
Radon (cont.)										
Effective radon diffusion coefficient of offsite dwelling site	m^2/s	P	2E-6	The value used in the deterministic run is the code default. The parameter has triangular distribution with the default as the mode in the distribution and the minimum value of the distribution is 1/10 of the default value, and the maximum value of the distribution is the maximum for uranium mill tailings from data collection handbook Table 4.1.1.	Triangular	2.00E-07	2.00E-06	7.00E-06	NR	See cover effective diffusion coefficient
Carbon-14										
Thickness of evasion layer for C-14 in soil	m	P	0.3	For deterministic run, the default value selected is the default used in the code. For probabilistic run, distribution from NUREG/CR-6697 is used.	Triangular	2.00E-01	3.00E-01	6.00E-01	NR	The maximum soil thickness layer through which C-14 can escape to the air by conversion to CO_2. C-14 below this depth cannot escape.

[a] For truncated lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution, parameter 3 = lower quantile, and parameter 4 = upper quantile; for lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution; for triangular distribution, parameter 1 = minimum, parameter 2 = mode or most likely, and parameter 3 = maximum; for truncated normal distribution, parameter 1 = mean, parameter 2 = standard deviation, parameter 3 = lower quantile, and parameter 4 = upper quantile; for bounded lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution, parameter 3 = minimum value, and parameter 4 = maximum value; for uniform distribution, parameter 1 = minimum, and parameter 2 = maximum; for continuous linear distribution, number of points, value of points, and CDF of points; for continuous logarithmic distribution, number of points, value of points, and CDF of points.

[b] P = physical, B= behavioral, and M = metabolic parameter.

[c] NR = not required.

Table B-57 Base Values and Statistical Distributions of Input Parameters Used in the RESRAD-OFFSITE Code for Offsite Resident via Air Transport Scenario Analysis (cont.)

Input screen title/parameter	Units	Type[b]	Base value for deterministic calculation	Source	Probabilistic analysis[a]					Description
					Distribution	Parameter 1	Parameter 2	Parameter 3	Parameter 4	
Carbon-14 (cont.)										
Vertical dimension of mixing for inhalation	m	P	2	The value used in the deterministic run is code default. The parameter has triangular distribution with the default as the mode in the distribution and the minimum value of the distribution is 1/2 of the default value, and the maximum value of the distribution is twice the default value.	Triangular	1.00E+00	2.00E+00	4.00E+00	NR	This vertical dimension together with the area of primary contamination is used to compute the onsite concentration of C-14 for inhalation.
Vertical dimension of mixing for vegetation	m	P	1	For deterministic run, base value selected is the code default. For probabilistic run, uniform distribution from 1/2 to twice the base value.	Uniform	0.5	2			This vertical dimension together with the area of primary contamination is used to compute the onsite concentration of C-14 for vegetation.
C-14 evasion flux rate from soil	1/s	P	0.0000007	The value used is from the default used in the code. The parameter has triangular distribution with the default as the mode in the distribution and the minimum value of the distribution is 1/2 of the default value, and the maximum value of the distribution is two times the default value.	Triangular	3.50E-07	7.00E-07	1.40E-06		The fraction of the soil inventory of C-14 lost to the atmosphere per unit time.

[a] For truncated lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution, parameter 3 = lower quantile, and parameter 4 = upper quantile; for lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution; for triangular distribution, parameter 1 = minimum, parameter 2 = mode or most likely, and parameter 3 = maximum; for truncated normal distribution, parameter 1 = mean, parameter 2 = standard deviation, parameter 3 = lower quantile, and parameter 4 = upper quantile; for bounded lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution, parameter 3 = minimum value, and parameter 4 = maximum value; for uniform distribution, parameter 1 = minimum, and parameter 2 = maximum; for continuous linear distribution, number of points, value of points, and CDF of points; for continuous logarithmic distribution, number of points, value of points, and CDF of points.

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[c] NR = not required.

Table B-57 Base Values and Statistical Distributions of Input Parameters Used in the RESRAD-OFFSITE Code for Offsite Resident via Air Transport Scenario Analysis (cont.)

Input screen title/parameter	Units	Type[b]	Base value for deterministic calculation	Source	Probabilistic analysis[a]					Description
					Distribution	Parameter 1	Parameter 2	Parameter 3	Parameter 4	
Carbon-14 (cont.)										
C-12 evasion flux rate from soil	1/s	P	1E-10	The value used is from the default used in the code. The parameter has triangular distribution with the default as the mode in the distribution and the minimum value of the distribution is 1/2 of the default value, and the maximum value of the distribution is two times the default value.	Triangular	5.00E-11	1.00E-10	2.00E-10		The fraction of C-12 in soil that escapes to the atmosphere per unit time.
Fraction of vegetation carbon absorbed from soil	—	P	0.02	The value used is from the default used in the code for fraction of vegetation carbon absorbed from soil. The parameter has triangular distribution with the default as the mode in the distribution and the minimum value of the distribution is 1/2 of the default value, and the maximum value of the distribution is two times the default value.	Triangular	1.00E-02	2.00E-02	4.00E-02		The fraction of total vegetation carbon obtained by direct root uptake from the soil.

[a] For truncated lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution, parameter 3 = lower quantile, and parameter 4 = upper quantile; for lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution; for triangular distribution, parameter 1 = minimum, parameter 2 = mode or most likely, and parameter 3 = maximum; for truncated normal distribution, parameter 1 = mean, parameter 2 = standard deviation, parameter 3 = lower quantile, and parameter 4 = upper quantile; for bounded lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution, parameter 3 = minimum value, and parameter 4 = maximum value; for uniform distribution, parameter 1 = minimum, and parameter 2 = maximum; for continuous linear distribution, number of points, value of points, and CDF of points; for continuous logarithmic distribution, number of points, value of points, and CDF of points.

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[c] NR = not required.

Table B-57 Base Values and Statistical Distributions of Input Parameters Used in the RESRAD-OFFSITE Code for Offsite Resident via Air Transport Scenario Analysis (cont.)

Input screen title/parameter	Units	Type[b]	Base value for deterministic calculation	Source	Probabilistic analysis[a]					Description
					Distribution	Parameter 1	Parameter 2	Parameter 3	Parameter 4	
Carbon-14 (cont.)										
Fraction of vegetation carbon absorbed from air	—	P	0.98	The value used is from the default used in the code for fraction of vegetation carbon absorbed from soil. The parameter has triangular distribution with the default as the mode in the distribution and the minimum and maximum value of the distribution were determined by using the maximum and minimum, respectively, of the previous parameter.	Triangular	9.60E-01	9.80E-01	9.90E-01		The fraction of total vegetation carbon assimilated from the atmosphere through photosynthesis.
Mass Fractions and Concentrations of Carbon-12										
C-12 concentration in atmosphere	g/m^3	P	0.18	For deterministic run, base value selected is the code default. For probabilistic run, uniform distribution from +/- 10 percent to the base value	Uniform	0.162	0.198			This parameter is the C-12 concentration in the atmosphere

[a] For truncated lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution, parameter 3 = lower quantile, and parameter 4 = upper quantile; for lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution; for triangular distribution, parameter 1 = minimum, parameter 2 = mode or most likely, and parameter 3 = maximum; for truncated normal distribution, parameter 1 = mean, parameter 2 = standard deviation, parameter 3 = lower quantile, and parameter 4 = upper quantile; for bounded lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution, parameter 3 = minimum value, and parameter 4 = maximum value; for uniform distribution, parameter 1 = minimum, and parameter 2 = maximum; for continuous linear distribution, number of points, value of points, and CDF of points; for continuous logarithmic distribution, number of points, value of points, and CDF of points.

[b] P = physical, B= behavioral, and M = metabolic parameter.

[c] NR = not required.

Table B-57 Base Values and Statistical Distributions of Input Parameters Used in the RESRAD-OFFSITE Code for Offsite Resident via Air Transport Scenario Analysis (cont.)

Input screen title/parameter	Units	Type[b]	Base value for deterministic calculation	Source	Probabilistic analysis[a]					Description
					Distribution	Parameter 1	Parameter 2	Parameter 3	Parameter 4	
Mass Fractions and Concentrations of Carbon-12 (cont.)										
C-12 concentration in contaminated soil	g/g	P	0.03	The value used is the code default. The parameter has triangular distribution with the default as the mode in the distribution and the minimum value of the distribution is 1/2 of the default value, and the maximum value of the distribution is two times the default value.	Triangular	1.50E-02	3.00E-02	6.00E-02		This parameter is the C-12 concentration in the contaminated zone in g/g.
C-12 concentration in local water	g/cm^3	P	2E-5	The value used is from the default used in the code for fraction of carbon in water. The parameter has triangular distribution with the default as the mode in the distribution and the minimum value of the distribution is 1/10 of the default value, and the maximum value of the distribution is ten times the default value.	Triangular	2.00E-06	2.00E-05	2.00E-04		This parameter is the C-12 concentration in the local water.

[a] For truncated lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution, parameter 3 = lower quantile, and parameter 4 = upper quantile; for lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution; for triangular distribution, parameter 1 = minimum, parameter 2 = mode or most likely, and parameter 3 = maximum; for truncated normal distribution, parameter 1 = mean, parameter 2 = standard deviation, parameter 3 = lower quantile, and parameter 4 = upper quantile; for bounded lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution, parameter 3 = minimum value, and parameter 4 = maximum value; for uniform distribution, parameter 1 = minimum, and parameter 2 = maximum; for continuous linear distribution, number of points, value of points, and CDF of points; for continuous logarithmic distribution, number of points, value of points, and CDF of points.

[b] P = physical, B= behavioral, and M = metabolic parameter.

[c] NR = not required.

Table B-57 Base Values and Statistical Distributions of Input Parameters Used in the RESRAD-OFFSITE Code for Offsite Resident via Air Transport Scenario Analysis (cont.)

Input screen title/parameter	Units	Type[b]	Base value for deterministic calculation	Source	Probabilistic analysis[a]					Description
					Distribution	Parameter 1	Parameter 2	Parameter 3	Parameter 4	
Mass Fractions and Concentrations of Carbon-12 (cont.)										
C-12 concentration in fruit, grain, non-leafy vegetables	—	P	0.4	For deterministic run, base value selected is the code default. For probabilistic run, uniform distribution from +/- 10 percent to the base value.	Uniform	0.36	0.44			The mass of C-12 in a unit mass of fruit, grain, and non-leafy vegetables.
C-12 concentration in leafy vegetables	—	P	0.09	For deterministic run, base value selected is the code default. For probabilistic run, uniform distribution from +/- 10 percent to the base value.	Uniform	0.081	0.099			The mass of C-12 in a unit mass of leafy vegetables.
C-12 concentration in pasture and silage	—	P	0.09	For deterministic run, base value selected is the code default. For probabilistic run, uniform distribution from +/- 10 percent to the base value.	Uniform	0.081	0.099			The mass of C-12 in a unit mass of pasture and silage.
C-12 concentration in grain	—	P	0.4	For deterministic run, base value selected is the code default. For probabilistic run, uniform distribution from +/- 10 percent to the base value.	Uniform	0.36	0.44			The mass of C-12 in a unit mass of grain.

[a] For truncated lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution, parameter 3 = lower quantile, and parameter 4 = upper quantile; for lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution; for triangular distribution, parameter 1 = minimum, parameter 2 = mode or most likely, and parameter 3 = maximum; for truncated normal distribution, parameter 1 = mean, parameter 2 = standard deviation, parameter 3 = lower quantile, and parameter 4 = upper quantile; for bounded lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution, parameter 3 = minimum value, and parameter 4 = maximum value; for uniform distribution, parameter 1 = minimum, and parameter 2 = maximum; for continuous linear distribution, number of points, value of points, and CDF of points; for continuous logarithmic distribution, number of points, value of points, and CDF of points.

[b] P = physical, B= behavioral, and M = metabolic parameter.

[c] NR = not required.

Table B-57 Base Values and Statistical Distributions of Input Parameters Used in the RESRAD-OFFSITE Code for Offsite Resident via Air Transport Scenario Analysis (cont.)

Input screen title/parameter	Units	Type[b]	Base value for deterministic calculation	Source	Probabilistic analysis[a]					Description
					Distribution	Parameter 1	Parameter 2	Parameter 3	Parameter 4	
Mass Fractions and Concentrations of Carbon-12 (cont.)										
C-12 concentration in meat	—	P	0.24	For deterministic run, base value selected is the code default. For probabilistic run, uniform distribution from +/- 10 percent to the base value.	Uniform	0.216	0.264			The mass of C-12 in a unit mass of meat.
C-12 concentration in milk	—	P	0.07	For deterministic run, base value selected is the code default. For probabilistic run, uniform distribution from +/- 10 percent to the base value.	Uniform	0.063	0.077			The mass of C-12 in a unit mass of milk.
Tritium										
Humidity in air	g/m^3	P	8	For deterministic run, base value selected is the code default. For probabilistic run, distribution from NUREG/CR-6697 is used.	Truncated lognormal-N	1.98	0.334	0.001	0.999	Air humidity is for the computation of tritium concentration in air.
Water fraction in fruit, grain, and non-leafy vegetables	—	P	0.8	For deterministic run, base value selected is the code default. For probabilistic run, uniform distribution from +/- 10 percent to the base value.	Uniform	0.72	0.88			The mass of water in a unit mass of fruit, grain, and non-leafy vegetables.

[a] For truncated lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution, parameter 3 = lower quantile, and parameter 4 = upper quantile; for lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution; for triangular distribution, parameter 1 = minimum, parameter 2 = mode or most likely, and parameter 3 = maximum; for truncated normal distribution, parameter 1 = mean, parameter 2 = standard deviation, parameter 3 = lower quantile, and parameter 4 = upper quantile; for bounded lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution, parameter 3 = minimum value, and parameter 4 = maximum value; for uniform distribution, parameter 1 = minimum, and parameter 2 = maximum; for continuous linear distribution, number of points, value of points, and CDF of points; for continuous logarithmic distribution, number of points, value of points, and CDF of points.

[b] P = physical, B= behavioral, and M = metabolic parameter.

[c] NR = not required.

Table B-57 Base Values and Statistical Distributions of Input Parameters Used in the RESRAD-OFFSITE Code for Offsite Resident via Air Transport Scenario Analysis (cont.)

Input screen title/parameter	Units	Type[b]	Base value for deterministic calculation	Source	Probabilistic analysis[a]					Description
					Distribution	Parameter 1	Parameter 2	Parameter 3	Parameter 4	
Tritium (cont.)										
Water fraction in leafy vegetable	—	P	0.8	For deterministic run, base value selected is the code default. For probabilistic run, uniform distribution from +/- 10 percent to the base value.	Uniform	0.72	0.88			The mass of water in a unit mass of leafy vegetables.
Water fraction in pasture and silage	—	P	0.8	For deterministic run, base value selected is the code default. For probabilistic run, uniform distribution from +/- 10 percent to the base value.	Uniform	0.72	0.88			The mass of water in a unit mass of pasture and silage.
Water fraction in grain	—	P	0.8	For deterministic run, base value selected is the code default. For probabilistic run, uniform distribution from +/- 10 percent to the base value.	Uniform	0.72	0.88			The mass of water in a unit mass of grain.
Water fraction in meat	—	P	0.6	For deterministic run, base value selected is the code default. For probabilistic run, uniform distribution from +/- 10 percent to the base value.	Uniform	0.54	0.66			The mass of water in a unit mass of meat.

[a] For truncated lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution, parameter 3 = lower quantile, and parameter 4 = upper quantile; for lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution; for triangular distribution, parameter 1 = minimum, parameter 2 = mode or most likely, and parameter 3 = maximum; for truncated normal distribution, parameter 1 = mean, parameter 2 = standard deviation, parameter 3 = lower quantile, and parameter 4 = upper quantile; for bounded lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution, parameter 3 = minimum value, and parameter 4 = maximum value; for uniform distribution, parameter 1 = minimum, and parameter 2 = maximum; for continuous linear distribution, number of points, value of points, and CDF of points; for continuous logarithmic distribution, number of points, value of points, and CDF of points.

[b] P = physical, B= behavioral, and M = metabolic parameter.

[c] NR = not required.

Table B-57 Base Values and Statistical Distributions of Input Parameters Used in the RESRAD-OFFSITE Code for Offsite Resident via Air Transport Scenario Analysis (cont.)

Input screen title/parameter	Units	Type[b]	Base value for deterministic calculation	Source	Probabilistic analysis[a]					Description
					Distribution	Parameter 1	Parameter 2	Parameter 3	Parameter 4	
Tritium (cont.)										
Water fraction in milk	—	P	0.88	For deterministic run, base value selected is the code default. For probabilistic run, uniform distribution from +/- 10 percent to the base value.	Uniform	0.792	0.968			The mass of water in a unit mass of milk.
Vertical dimension of mixing for inhalation	m	P	2	The value used in the deterministic run is code default. The parameter has triangular distribution with the default as the mode in the distribution and the minimum value of the distribution is 1/2 of the default value, and the maximum value of the distribution is twice the default value.	Triangular	1	2	4	NR	This vertical dimension together with the area of primary contamination defines the mixing volume used to compute the onsite concentration of H-3 for inhalation.

[a] For truncated lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution, parameter 3 = lower quantile, and parameter 4 = upper quantile; for lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution; for triangular distribution, parameter 1 = minimum, parameter 2 = mode or most likely, and parameter 3 = maximum; for truncated normal distribution, parameter 1 = mean, parameter 2 = standard deviation, parameter 3 = lower quantile, and parameter 4 = upper quantile; for bounded lognormal-n distribution, parameter 1 = mean of the underlying normal distribution, parameter 2 = standard deviation of the underlying normal distribution, parameter 3 = minimum value, and parameter 4 = maximum value; for uniform distribution, parameter 1 = minimum, and parameter 2 = maximum; for continuous linear distribution, number of points, value of points, and CDF of points; for continuous logarithmic distribution, number of points, value of points, and CDF of points.

[b] P = physical, B= behavioral, and M = metabolic parameter.

[c] NR = not required.

Table B-58 Distributions of Peak Total Dose and Peak Pathway Dose Obtained with Probabilistic Calculations for Offsite Resident via Air Transport Scenario Concerning C-14 Contamination (mrem/yr per pCi/g)

Percentile	Peak total dose	Water release							CZ and air[a]					
		External ground	Fish ingestion	Plant ingestion	Meat ingestion	Milk ingestion	Soil Ingestion	Water ingestion	External ground	Inhalation	Plant ingestion	Meat ingestion	Milk ingestion	Soil ingestion
5	1.31E-03	1.44E-14	2.97E-06	6.78E-09	3.09E-09	1.56E-09	1.38E-13	1.76E-09	2.29E-09	3.29E-04	5.35E-04	1.81E-04	5.14E-05	1.05E-16
10	1.49E-03	3.77E-14	8.32E-06	1.75E-08	8.14E-09	4.04E-09	3.63E-13	4.75E-09	2.47E-09	3.62E-04	6.03E-04	2.04E-04	5.75E-05	5.43E-16
15	1.63E-03	7.16E-14	1.76E-05	3.32E-08	1.65E-08	8.07E-09	6.86E-13	9.59E-09	2.63E-09	3.90E-04	6.47E-04	2.20E-04	6.20E-05	1.93E-15
20	1.76E-03	1.17E-13	3.10E-05	5.92E-08	2.72E-08	1.37E-08	1.12E-12	1.61E-08	2.79E-09	4.16E-04	6.92E-04	2.33E-04	6.59E-05	5.52E-15
25	1.88E-03	1.92E-13	5.01E-05	9.55E-08	4.33E-08	2.21E-08	1.86E-12	2.66E-08	2.96E-09	4.41E-04	7.35E-04	2.46E-04	6.97E-05	1.36E-14
30	1.98E-03	2.90E-13	7.84E-05	1.36E-07	6.37E-08	3.25E-08	2.77E-12	4.11E-08	3.11E-09	4.64E-04	7.70E-04	2.58E-04	7.32E-05	2.95E-14
35	2.10E-03	4.22E-13	1.21E-04	1.96E-07	9.16E-08	4.55E-08	4.08E-12	5.85E-08	3.27E-09	4.87E-04	8.05E-04	2.70E-04	7.65E-05	5.88E-14
40	2.21E-03	5.86E-13	1.76E-04	2.79E-07	1.31E-07	6.43E-08	5.71E-12	8.06E-08	3.42E-09	5.06E-04	8.41E-04	2.82E-04	7.95E-05	1.17E-13
45	2.34E-03	8.13E-13	2.42E-04	3.81E-07	1.77E-07	8.71E-08	7.88E-12	1.12E-07	3.58E-09	5.26E-04	8.75E-04	2.93E-04	8.28E-05	2.37E-13
50	2.47E-03	1.09E-12	3.39E-04	5.15E-07	2.40E-07	1.21E-07	1.08E-11	1.60E-07	3.74E-09	5.47E-04	9.10E-04	3.05E-04	8.63E-05	4.60E-13
55	2.63E-03	1.50E-12	4.73E-04	7.21E-07	3.34E-07	1.64E-07	1.45E-11	2.14E-07	3.93E-09	5.69E-04	9.48E-04	3.17E-04	8.97E-05	8.80E-13
60	2.79E-03	2.05E-12	6.50E-04	9.80E-07	4.67E-07	2.28E-07	2.00E-11	2.88E-07	4.12E-09	5.92E-04	9.88E-04	3.30E-04	9.33E-05	1.84E-12
65	3.02E-03	2.76E-12	9.15E-04	1.36E-06	6.47E-07	3.17E-07	2.68E-11	3.98E-07	4.32E-09	6.16E-04	1.02E-03	3.41E-04	9.66E-05	3.72E-12
70	3.38E-03	3.90E-12	1.34E-03	1.88E-06	9.01E-07	4.32E-07	3.79E-11	5.51E-07	4.53E-09	6.40E-04	1.06E-03	3.55E-04	1.00E-04	8.00E-12
75	3.96E-03	5.50E-12	2.00E-03	2.71E-06	1.24E-06	6.02E-07	5.32E-11	7.87E-07	4.78E-09	6.63E-04	1.10E-03	3.72E-04	1.05E-04	1.79E-11
80	4.95E-03	7.92E-12	3.07E-03	3.87E-06	1.80E-06	8.42E-07	7.86E-11	1.15E-06	5.09E-09	6.92E-04	1.15E-03	3.88E-04	1.09E-04	4.73E-11
85	6.66E-03	1.22E-11	4.75E-03	6.05E-06	2.71E-06	1.31E-06	1.20E-10	1.69E-06	5.47E-09	7.24E-04	1.21E-03	4.10E-04	1.16E-04	1.33E-10
90	1.08E-02	2.07E-11	8.88E-03	9.98E-06	4.86E-06	2.26E-06	2.02E-10	2.86E-06	5.95E-09	7.65E-04	1.29E-03	4.41E-04	1.23E-04	4.08E-10
95	2.27E-02	4.38E-11	2.06E-02	2.10E-05	1.08E-05	5.00E-06	4.31E-10	6.20E-06	6.61E-09	8.28E-04	1.40E-03	4.86E-04	1.34E-04	1.56E-09
max	3.09E+00	2.67E-09	3.09E+00	1.53E-03	1.04E-03	3.55E-04	2.59E-08	3.83E-04	1.02E-08	1.11E-03	2.05E-03	7.37E-04	2.09E-04	6.08E-08
mean	7.92E-03	1.27E-11	6.05E-03	6.34E-06	3.08E-06	1.37E-06	1.26E-10	1.74E-06	4.00E-09	5.58E-04	9.32E-04	3.15E-04	8.86E-05	4.26E-10
95/50	9.19E+00	4.00E+01	6.09E+01	4.08E+01	4.52E+01	4.15E+01	3.98E+01	3.87E+01	1.77E+00	1.51E+00	1.54E+00	1.60E+00	1.55E+00	3.40E+03
95 - 50	2.02E-02	4.27E-11	2.03E-02	2.05E-05	1.06E-05	4.88E-06	4.20E-10	6.04E-06	2.87E-09	2.80E-04	4.93E-04	1.82E-04	4.78E-05	1.56E-09

a Dose directly from primary contamination and air transport.

Note: Any pathway with 50th or 95th percentile dose that is more than 5 percent of the 50th or 95th percentile dose from all pathways, respectively was considered significant in this analysis and is highlighted. Different colors are used in different rows.

Table B-59 Distributions of Peak Total Dose and Peak Pathway Dose Obtained with Probabilistic Calculations for Offsite Resident via Air Transport Scenario Concerning Co-60 Contamination (mrem/yr per pCi/g)

Percentile	Peak total dose	Water release							CZ and air[a]					
		External ground	Fish ingestion	Plant ingestion	Meat ingestion	Milk ingestion	Soil ingestion	Water ingestion	External ground	Inhalation	Plant ingestion	Meat ingestion	Milk ingestion	Soil ingestion
5	3.81E-02	5.56E-08	2.25E-08	8.84E-09	4.12E-10	3.85E-10	4.05E-12	1.71E-08	3.81E-02	2.52E-10	1.46E-15	8.71E-20	8.85E-21	1.27E-14
10	3.81E-02	1.79E-07	7.36E-08	2.81E-08	1.47E-09	1.41E-09	1.29E-11	5.65E-08	3.81E-02	2.21E-09	1.38E-12	4.87E-15	1.18E-15	6.63E-14
15	3.81E-02	3.84E-07	1.57E-07	6.10E-08	3.07E-09	2.98E-09	2.88E-11	1.18E-07	3.81E-02	1.57E-08	1.16E-11	6.93E-14	2.54E-14	2.36E-13
20	3.81E-02	6.57E-07	2.75E-07	1.11E-07	5.75E-09	5.44E-09	4.86E-11	2.07E-07	3.81E-02	6.69E-08	4.57E-11	3.01E-13	1.29E-13	6.00E-13
25	3.81E-02	1.10E-06	4.72E-07	1.87E-07	1.00E-08	8.72E-09	8.35E-11	3.52E-07	3.81E-02	1.65E-07	1.48E-10	1.07E-12	4.16E-13	1.51E-12
30	3.81E-02	1.78E-06	7.37E-07	2.89E-07	1.59E-08	1.41E-08	1.34E-10	5.59E-07	3.81E-02	2.54E-07	3.86E-10	2.67E-12	1.16E-12	3.27E-12
35	3.81E-02	2.72E-06	1.10E-06	4.38E-07	2.46E-08	2.16E-08	1.99E-10	8.32E-07	3.81E-02	3.21E-07	8.60E-10	6.44E-12	2.81E-12	6.43E-12
40	3.81E-02	3.92E-06	1.62E-06	6.43E-07	3.56E-08	3.22E-08	2.88E-10	1.23E-06	3.81E-02	3.73E-07	1.91E-09	1.47E-11	6.62E-12	1.23E-11
45	3.81E-02	5.57E-06	2.32E-06	9.30E-07	5.15E-08	4.54E-08	4.12E-10	1.78E-06	3.81E-02	4.20E-07	3.93E-09	3.51E-11	1.34E-11	2.41E-11
50	3.81E-02	7.67E-06	3.36E-06	1.32E-06	7.27E-08	6.57E-08	5.82E-10	2.51E-06	3.81E-02	4.67E-07	8.12E-09	7.38E-11	2.83E-11	4.74E-11
55	3.81E-02	1.08E-05	4.63E-06	1.82E-06	1.05E-07	9.25E-08	8.08E-10	3.51E-06	3.81E-02	5.12E-07	1.69E-08	1.51E-10	6.26E-11	1.00E-10
60	3.81E-02	1.45E-05	6.64E-06	2.62E-06	1.54E-07	1.35E-07	1.11E-09	4.96E-06	3.81E-02	5.61E-07	3.57E-08	3.06E-10	1.42E-10	1.89E-10
65	3.81E-02	2.04E-05	9.09E-06	3.65E-06	2.18E-07	1.89E-07	1.57E-09	6.91E-06	3.81E-02	6.09E-07	7.31E-08	6.58E-10	3.02E-10	4.01E-10
70	3.81E-02	2.94E-05	1.30E-05	5.14E-06	3.12E-07	2.71E-07	2.21E-09	9.88E-06	3.81E-02	6.64E-07	1.64E-07	1.60E-09	6.96E-10	8.76E-10
75	3.81E-02	4.20E-05	1.90E-05	7.56E-06	4.66E-07	4.05E-07	3.12E-09	1.42E-05	3.81E-02	7.24E-07	4.24E-07	3.92E-09	1.73E-09	1.95E-09
80	3.82E-02	6.22E-05	2.86E-05	1.11E-05	6.94E-07	6.25E-07	4.85E-09	2.10E-05	3.81E-02	7.96E-07	1.14E-06	1.00E-08	4.40E-09	4.94E-09
85	3.82E-02	9.64E-05	4.48E-05	1.72E-05	1.13E-06	1.03E-06	7.43E-09	3.23E-05	3.81E-02	8.83E-07	2.95E-06	2.88E-08	1.21E-08	1.25E-08
90	3.84E-02	1.70E-04	8.07E-05	3.01E-05	2.07E-06	1.93E-06	1.33E-08	5.68E-05	3.81E-02	1.00E-06	9.55E-06	8.66E-08	3.77E-08	4.16E-08
95	3.88E-02	3.80E-04	1.84E-04	6.92E-05	5.11E-06	4.38E-06	2.97E-08	1.33E-04	3.84E-02	1.20E-06	4.30E-05	4.17E-07	1.59E-07	1.71E-07
max	1.49E-01	4.09E-02	5.02E-02	1.52E-02	1.46E-03	4.19E-04	3.82E-06	2.95E-02	9.11E-02	2.59E-06	1.25E-03	3.12E-05	1.79E-05	1.35E-05
mean	3.83E-02	1.10E-04	5.87E-05	2.14E-05	1.78E-06	1.31E-06	8.91E-09	4.02E-05	3.82E-02	4.94E-07	1.08E-05	1.35E-07	5.48E-08	4.67E-08
95/50	1.02E+00	4.96E+01	5.46E+01	5.26E+01	7.03E+01	6.66E+01	5.10E+01	5.31E+01	1.01E+00	2.56E+00	5.30E+03	5.65E+03	5.63E+03	3.60E+03
95 - 50	7.62E-04	3.73E-04	1.80E-04	6.79E-05	5.04E-06	4.31E-06	2.91E-08	1.31E-04	3.45E-04	7.29E-07	4.30E-05	4.17E-07	1.59E-07	1.71E-07

a Dose directly from primary contamination and air transport.

Note: Any pathway with 50th or 95th percentile dose that is more than 5 percent of the 50th or 95th percentile dose from all pathways, respectively was considered significant in this analysis and is highlighted. Different colors are used in different rows.

Table B-60 Distributions of Peak Total Dose and Peak Pathway Dose Obtained with Probabilistic Calculations for Offsite Resident via Air Transport Scenario Concerning Cs-137 Contamination (mrem/yr per pCi/g)

Percentile	Peak total dose	Water release							CZ and air[a]					
		External ground	Fish ingestion	Plant ingestion	Meat ingestion	Milk ingestion	Soil ingestion	Water ingestion	External ground	Inhalation	Plant ingestion	Meat ingestion	Milk ingestion	Soil ingestion
5	9.35E-03	1.53E-07	1.02E-06	5.05E-08	1.06E-07	8.91E-08	1.07E-10	9.70E-08	9.35E-03	8.75E-10	3.00E-15	1.35E-17	1.04E-18	1.63E-13
10	9.35E-03	4.08E-07	2.83E-06	1.44E-07	3.43E-07	2.44E-07	2.82E-10	2.52E-07	9.35E-03	5.73E-09	4.61E-12	9.07E-13	1.46E-13	7.52E-13
15	9.35E-03	7.35E-07	5.60E-06	2.65E-07	6.87E-07	5.04E-07	5.06E-10	4.70E-07	9.35E-03	2.74E-08	3.75E-11	1.05E-11	2.64E-12	2.59E-12
20	9.35E-03	1.31E-06	9.89E-06	4.81E-07	1.19E-06	8.87E-07	9.26E-10	8.71E-07	9.35E-03	9.47E-08	1.52E-10	5.05E-11	1.32E-11	7.92E-12
25	9.35E-03	2.22E-06	1.61E-05	7.96E-07	1.97E-06	1.44E-06	1.55E-09	1.40E-06	9.35E-03	2.36E-07	4.84E-10	1.79E-10	4.83E-11	2.04E-11
30	9.36E-03	3.25E-06	2.52E-05	1.15E-06	3.05E-06	2.23E-06	2.32E-09	2.08E-06	9.35E-03	3.46E-07	1.31E-09	4.94E-10	1.33E-10	4.33E-11
35	9.36E-03	4.85E-06	3.61E-05	1.69E-06	4.47E-06	3.36E-06	3.48E-09	3.02E-06	9.35E-03	4.32E-07	3.18E-09	1.22E-09	3.77E-10	8.93E-11
40	9.37E-03	6.84E-06	5.06E-05	2.39E-06	6.61E-06	4.91E-06	4.80E-09	4.27E-06	9.35E-03	5.05E-07	6.81E-09	3.04E-09	8.88E-10	1.88E-10
45	9.38E-03	9.49E-06	7.18E-05	3.45E-06	9.54E-06	6.95E-06	6.64E-09	5.76E-06	9.35E-03	5.67E-07	1.47E-08	6.90E-09	1.86E-09	3.85E-10
50	9.40E-03	1.30E-05	1.01E-04	4.65E-06	1.39E-05	9.55E-06	9.26E-09	8.13E-06	9.35E-03	6.22E-07	3.17E-08	1.50E-08	3.95E-09	7.00E-10
55	9.42E-03	1.77E-05	1.46E-04	6.40E-06	1.87E-05	1.31E-05	1.28E-08	1.11E-05	9.35E-03	6.81E-07	6.82E-08	3.16E-08	8.81E-09	1.33E-09
60	9.45E-03	2.39E-05	2.01E-04	8.76E-06	2.52E-05	1.79E-05	1.71E-08	1.54E-05	9.35E-03	7.43E-07	1.43E-07	6.76E-08	1.96E-08	2.77E-09
65	9.51E-03	3.32E-05	2.84E-04	1.18E-05	3.54E-05	2.48E-05	2.38E-08	2.12E-05	9.35E-03	8.06E-07	3.16E-07	1.40E-07	4.39E-08	5.53E-09
70	9.61E-03	4.57E-05	4.12E-04	1.70E-05	5.00E-05	3.56E-05	3.24E-08	2.97E-05	9.35E-03	8.76E-07	7.09E-07	3.33E-07	9.67E-08	1.16E-08
75	9.87E-03	6.38E-05	6.06E-04	2.38E-05	7.51E-05	5.06E-05	4.61E-08	4.18E-05	9.35E-03	9.57E-07	1.61E-06	7.51E-07	2.32E-07	2.53E-08
80	1.03E-02	9.47E-05	9.06E-04	3.49E-05	1.10E-04	7.88E-05	6.79E-08	6.23E-05	9.35E-03	1.05E-06	3.95E-06	1.78E-06	5.25E-07	6.96E-08
85	1.12E-02	1.46E-04	1.42E-03	5.37E-05	1.76E-04	1.19E-04	1.06E-07	9.47E-05	9.35E-03	1.17E-06	1.11E-05	5.36E-06	1.41E-06	1.76E-07
90	1.36E-02	2.56E-04	2.53E-03	9.08E-05	3.08E-04	2.13E-04	1.84E-07	1.53E-04	9.37E-03	1.33E-06	3.88E-05	2.05E-05	4.53E-06	5.60E-07
95	2.11E-02	5.61E-04	6.05E-03	2.02E-04	7.49E-04	4.79E-04	4.17E-07	3.64E-04	9.46E-03	1.60E-06	1.75E-04	9.39E-05	2.40E-05	2.46E-06
max	8.13E-01	4.54E-02	5.34E-01	4.22E-02	6.54E-02	1.58E-01	3.04E-05	7.57E-02	1.16E-01	6.17E-06	2.71E-02	6.47E-03	1.52E-03	1.87E-04
mean	1.21E-02	1.53E-04	1.90E-03	6.45E-05	2.34E-04	1.76E-04	1.16E-07	1.07E-04	9.83E-03	6.62E-07	5.38E-05	3.10E-05	7.08E-06	6.70E-07
95/50	2.25E+00	4.33E+01	5.96E+01	4.36E+01	5.39E+01	5.02E+01	4.50E+01	4.47E+01	1.01E+00	2.58E+00	5.53E+03	6.26E+03	6.08E+03	3.51E+03
95 - 50	1.17E-02	5.48E-04	5.95E-03	1.98E-04	7.35E-04	4.70E-04	4.08E-07	3.56E-04	1.14E-04	9.82E-07	1.75E-04	9.39E-05	2.40E-05	2.46E-06

[a] Dose directly from primary contamination and air transport.

Note: Any pathway with 50th or 95th percentile dose that is more than 5 percent of the 50th or 95th percentile dose from all pathways, respectively was considered significant in this analysis and is highlighted. Different colors are used in different rows.

Table B-61 Distributions of Peak Total Dose and Peak Pathway Dose Obtained with Probabilistic Calculations for Offsite Resident via Air Transport Scenario Concerning H-3 Contamination (mrem/yr per pCi/g)

Percentile	Peak total dose	Water release							CZ and air[a]					
		External ground	Fish ingestion	Plant ingestion	Meat ingestion	Milk ingestion	Soil ingestion	Water ingestion	External ground	Inhalation	Plant ingestion	Meat ingestion	Milk ingestion	Soil ingestion
5	3.59E-03	0.00E+00	6.70E-12	1.20E-10	7.09E-11	1.69E-10	1.30E-14	1.09E-09	0.00E+00	3.59E-03	1.12E-17	1.18E-20	3.04E-21	5.85E-18
10	4.18E-03	0.00E+00	1.63E-11	2.88E-10	1.66E-10	3.97E-10	3.20E-14	2.64E-09	0.00E+00	4.18E-03	1.65E-14	8.18E-16	4.15E-16	3.52E-17
15	4.67E-03	0.00E+00	2.98E-11	5.29E-10	3.13E-10	7.35E-10	5.82E-14	4.82E-09	0.00E+00	4.67E-03	1.32E-13	9.34E-15	8.00E-15	1.29E-16
20	5.07E-03	0.00E+00	4.87E-11	8.90E-10	5.17E-10	1.19E-09	9.98E-14	7.90E-09	0.00E+00	5.07E-03	5.76E-13	5.41E-14	4.91E-14	3.53E-16
25	5.49E-03	0.00E+00	7.65E-11	1.38E-09	8.20E-10	1.87E-09	1.51E-13	1.24E-08	0.00E+00	5.49E-03	1.94E-12	1.89E-13	1.77E-13	8.16E-16
30	5.86E-03	0.00E+00	1.14E-10	2.03E-09	1.21E-09	2.80E-09	2.26E-13	1.84E-08	0.00E+00	5.86E-03	5.49E-12	5.16E-13	5.22E-13	1.71E-15
35	6.19E-03	0.00E+00	1.60E-10	2.92E-09	1.66E-09	3.89E-09	3.15E-13	2.59E-08	0.00E+00	6.19E-03	1.18E-11	1.20E-12	1.19E-12	3.62E-15
40	6.53E-03	0.00E+00	2.13E-10	3.94E-09	2.23E-09	5.17E-09	4.23E-13	3.44E-08	0.00E+00	6.53E-03	2.62E-11	2.60E-12	2.58E-12	7.25E-15
45	6.87E-03	0.00E+00	2.82E-10	5.44E-09	3.00E-09	7.05E-09	5.75E-13	4.59E-08	0.00E+00	6.87E-03	5.31E-11	5.63E-12	5.83E-12	1.39E-14
50	7.25E-03	0.00E+00	3.86E-10	7.43E-09	4.08E-09	9.56E-09	7.89E-13	6.26E-08	0.00E+00	7.25E-03	1.09E-10	1.24E-11	1.23E-11	2.59E-14
55	7.63E-03	0.00E+00	5.23E-10	9.96E-09	5.42E-09	1.28E-08	1.03E-12	8.47E-08	0.00E+00	7.63E-03	2.32E-10	2.58E-11	2.51E-11	5.09E-14
60	8.08E-03	0.00E+00	7.04E-10	1.31E-08	7.42E-09	1.73E-08	1.43E-12	1.14E-07	0.00E+00	8.08E-03	5.06E-10	5.52E-11	5.75E-11	9.94E-14
65	8.55E-03	0.00E+00	9.53E-10	1.75E-08	1.03E-08	2.38E-08	1.96E-12	1.54E-07	0.00E+00	8.55E-03	1.05E-09	1.17E-10	1.16E-10	2.04E-13
70	9.05E-03	0.00E+00	1.30E-09	2.43E-08	1.35E-08	3.23E-08	2.65E-12	2.11E-07	0.00E+00	9.05E-03	2.31E-09	2.64E-10	2.56E-10	4.11E-13
75	9.55E-03	0.00E+00	1.78E-09	3.43E-08	1.90E-08	4.41E-08	3.70E-12	2.88E-07	0.00E+00	9.54E-03	5.29E-09	5.69E-10	5.79E-10	9.70E-13
80	1.02E-02	0.00E+00	2.50E-09	4.82E-08	2.68E-08	6.25E-08	5.25E-12	4.06E-07	0.00E+00	1.02E-02	1.37E-08	1.48E-09	1.47E-09	2.39E-12
85	1.08E-02	0.00E+00	3.73E-09	7.16E-08	4.01E-08	9.24E-08	7.95E-12	6.06E-07	0.00E+00	1.08E-02	3.88E-08	4.21E-09	4.20E-09	6.29E-12
90	1.17E-02	0.00E+00	6.03E-09	1.20E-07	6.83E-08	1.52E-07	1.30E-11	9.77E-07	0.00E+00	1.17E-02	1.16E-07	1.29E-08	1.37E-08	1.95E-11
95	1.31E-02	0.00E+00	1.35E-08	2.65E-07	1.44E-07	3.30E-07	2.84E-11	2.18E-06	0.00E+00	1.31E-02	4.94E-07	5.69E-08	5.82E-08	7.86E-11
max	2.21E-02	0.00E+00	7.03E-07	1.93E-05	8.40E-06	1.83E-05	2.45E-09	1.14E-04	0.00E+00	2.21E-02	2.72E-05	2.14E-06	2.45E-06	3.94E-09
Mean	7.68E-03	0.00E+00	3.75E-09	7.70E-08	4.07E-08	9.29E-08	8.34E-12	6.09E-07	0.00E+00	7.68E-03	1.38E-07	1.44E-08	1.45E-08	2.12E-11
95/50	1.80E+00	NA	3.49E+01	3.57E+01	3.52E+01	3.46E+01	3.60E+01	3.49E+01	NA	1.80E+00	4.52E+03	4.61E+03	4.73E+03	3.03E+03
95 - 50	5.82E-03	0.00E+00	1.31E-08	2.58E-07	1.40E-07	3.21E-07	2.76E-11	2.12E-06	0.00E+00	5.82E-03	4.93E-07	5.69E-08	5.82E-08	7.86E-11

[a] Dose directly from primary contamination and air transport.

Note: Any pathway with 50th or 95th percentile dose that is more than 5 percent of the 50th or 95th percentile dose from all pathways, respectively was considered significant in this analysis and is highlighted. Different colors are used in different rows.

Table B-62 Distributions of Peak Total Dose and Peak Pathway Dose Obtained with Probabilistic Calculations for Offsite Resident via Air Transport Scenario Concerning I-129 Contamination (mrem/yr per pCi/g)

Percentile	Peak total dose	Water release							CZ and air[a]					
		External ground	Fish ingestion	Plant ingestion	Meat ingestion	Milk ingestion	Soil ingestion	Water ingestion	External ground	Inhalation	Plant ingestion	Meat ingestion	Milk ingestion	Soil ingestion
5	2.78E-05	8.55E-10	9.34E-07	1.90E-06	1.27E-06	3.58E-06	1.80E-09	3.77E-06	5.68E-06	2.86E-09	1.57E-14	2.40E-17	9.45E-18	8.59E-13
10	5.96E-05	2.23E-09	2.39E-06	4.88E-06	3.16E-06	1.01E-05	4.61E-09	9.68E-06	5.68E-06	1.60E-08	3.33E-11	1.81E-12	1.52E-12	4.13E-12
15	1.08E-04	4.09E-09	4.42E-06	9.41E-06	6.63E-06	2.08E-05	8.45E-09	1.76E-05	5.68E-06	6.86E-08	2.55E-10	2.22E-11	2.33E-11	1.60E-11
20	1.82E-04	6.85E-09	7.75E-06	1.57E-05	1.16E-05	3.64E-05	1.43E-08	2.94E-05	5.68E-06	2.47E-07	1.12E-09	1.14E-10	1.37E-10	4.52E-11
25	2.73E-04	1.09E-08	1.24E-05	2.41E-05	1.85E-05	5.83E-05	2.25E-08	4.72E-05	5.68E-06	5.86E-07	3.74E-09	3.77E-10	5.12E-10	1.07E-10
30	4.04E-04	1.62E-08	1.81E-05	3.69E-05	2.87E-05	8.81E-05	3.40E-08	7.14E-05	5.68E-06	9.14E-07	1.02E-08	1.18E-09	1.55E-09	2.42E-10
35	5.58E-04	2.32E-08	2.68E-05	5.22E-05	4.11E-05	1.26E-04	4.87E-08	9.97E-05	5.68E-06	1.14E-06	2.43E-08	3.11E-09	3.74E-09	4.89E-10
40	7.85E-04	3.25E-08	3.68E-05	7.26E-05	5.99E-05	1.78E-04	6.72E-08	1.38E-04	5.68E-06	1.32E-06	5.13E-08	6.93E-09	8.55E-09	9.02E-10
45	1.08E-03	4.49E-08	5.03E-05	1.01E-04	8.43E-05	2.44E-04	9.32E-08	1.92E-04	5.68E-06	1.48E-06	1.07E-07	1.58E-08	1.92E-08	1.78E-09
50	1.49E-03	6.11E-08	7.16E-05	1.39E-04	1.21E-04	3.27E-04	1.28E-07	2.64E-04	5.68E-06	1.65E-06	2.21E-07	3.14E-08	4.22E-08	3.40E-09
55	1.95E-03	8.21E-08	9.73E-05	1.89E-04	1.70E-04	4.53E-04	1.72E-07	3.53E-04	5.68E-06	1.81E-06	4.43E-07	7.01E-08	8.89E-08	6.85E-09
60	2.55E-03	1.13E-07	1.29E-04	2.53E-04	2.34E-04	6.28E-04	2.36E-07	4.79E-04	5.69E-06	1.98E-06	9.80E-07	1.42E-07	1.90E-07	1.36E-08
65	3.56E-03	1.52E-07	1.75E-04	3.40E-04	3.37E-04	8.58E-04	3.20E-07	6.54E-04	5.69E-06	2.14E-06	2.25E-06	3.13E-07	4.16E-07	2.60E-08
70	4.75E-03	2.06E-07	2.42E-04	4.63E-04	4.79E-04	1.26E-03	4.29E-07	8.74E-04	5.71E-06	2.33E-06	4.62E-06	6.96E-07	9.64E-07	5.61E-08
75	6.63E-03	2.81E-07	3.38E-04	6.57E-04	7.07E-04	1.89E-03	5.87E-07	1.21E-03	5.74E-06	2.55E-06	1.07E-05	1.79E-06	2.28E-06	1.42E-07
80	9.43E-03	4.17E-07	5.05E-04	9.41E-04	1.11E-03	2.88E-03	8.77E-07	1.77E-03	5.83E-06	2.80E-06	2.82E-05	4.71E-06	5.11E-06	3.40E-07
85	1.38E-02	6.44E-07	8.02E-04	1.46E-03	1.81E-03	4.55E-03	1.34E-06	2.73E-03	6.11E-06	3.11E-06	8.19E-05	1.31E-05	1.65E-05	9.62E-07
90	2.31E-02	1.10E-06	1.37E-03	2.46E-03	3.47E-03	8.09E-03	2.31E-06	4.60E-03	7.05E-06	3.54E-06	2.72E-04	4.72E-05	5.79E-05	3.14E-06
95	4.98E-02	2.38E-06	3.05E-03	5.43E-03	8.33E-03	1.82E-02	4.95E-06	1.00E-02	1.13E-05	4.22E-06	1.24E-03	2.33E-04	2.73E-04	1.30E-05
max	6.34E+00	1.10E-04	1.44E-01	3.71E-01	9.84E-01	4.19E+00	2.38E-04	7.18E-01	1.21E-04	1.08E-05	3.92E-02	1.91E-02	1.80E-02	2.65E-04
mean	1.33E-02	5.65E-07	7.90E-04	1.34E-03	2.50E-03	5.72E-03	1.19E-06	2.49E-03	7.03E-06	1.75E-06	3.17E-04	8.16E-05	8.23E-05	3.10E-06
95/50	3.35E+01	3.89E+01	4.26E+01	3.91E+01	6.88E+01	5.57E+01	3.88E+01	3.81E+01	1.98E+00	2.57E+00	5.63E+03	7.43E+03	6.46E+03	3.81E+03
95 - 50	4.84E-02	2.31E-06	2.98E-03	5.29E-03	8.21E-03	1.79E-02	4.82E-06	9.78E-03	5.58E-06	2.58E-06	1.24E-03	2.33E-04	2.73E-04	1.30E-05

[a] Dose directly from primary contamination and air transport.

Note: Any pathway with 50th or 95th percentile dose that is more than 5 percent of the 50th or 95th percentile dose from all pathways, respectively was considered significant in this analysis and is highlighted. Different colors are used in different rows.

Table B-63 Distributions of Peak Total Dose and Peak Pathway Dose Obtained with Probabilistic Calculations for Offsite Resident via Air Transport Scenario Concerning Np-237 Contamination (mrem/yr per pCi/g)

Percentile	Peak total Dose	Water release							CZ and air[a]					
		External ground	Fish ingestion	Plant ingestion	Meat ingestion	Milk ingestion	Soil ingestion	Water ingestion	External ground	Inhalation	Plant ingestion	Meat ingestion	Milk ingestion	Soil ingestion
5	3.07E-03	3.71E-07	3.06E-05	2.07E-06	2.33E-07	8.45E-09	6.70E-09	3.58E-06	2.70E-03	2.75E-06	4.01E-11	4.84E-13	6.30E-14	3.57E-12
10	3.43E-03	9.14E-07	7.34E-05	4.87E-06	6.29E-07	2.10E-08	1.64E-08	8.57E-06	2.70E-03	1.45E-05	2.61E-10	4.05E-12	3.89E-13	1.89E-11
15	3.69E-03	1.70E-06	1.39E-04	9.89E-06	1.14E-06	4.27E-08	3.02E-08	1.62E-05	2.70E-03	5.90E-05	1.07E-09	1.94E-11	1.19E-12	7.20E-11
20	3.95E-03	2.77E-06	2.26E-04	1.60E-05	1.84E-06	6.61E-08	5.05E-08	2.62E-05	2.70E-03	1.55E-04	3.85E-09	6.87E-11	3.29E-12	1.97E-10
25	4.20E-03	4.46E-06	3.55E-04	2.53E-05	2.88E-06	1.06E-07	8.14E-08	4.15E-05	2.70E-03	3.17E-04	1.01E-08	1.78E-10	7.44E-12	4.99E-10
30	4.50E-03	6.53E-06	5.34E-04	3.70E-05	4.27E-06	1.64E-07	1.19E-07	6.23E-05	2.70E-03	4.41E-04	2.37E-08	4.52E-10	1.63E-11	1.03E-09
35	4.84E-03	9.33E-06	7.39E-04	5.29E-05	6.42E-06	2.33E-07	1.67E-07	8.64E-05	2.70E-03	5.47E-04	5.12E-08	9.95E-10	3.39E-11	1.96E-09
40	5.25E-03	1.27E-05	1.03E-03	7.22E-05	9.19E-06	3.21E-07	2.27E-07	1.20E-04	2.70E-03	6.26E-04	1.02E-07	2.05E-09	7.02E-11	3.94E-09
45	5.82E-03	1.75E-05	1.43E-03	1.01E-04	1.26E-05	4.49E-07	3.20E-07	1.66E-04	2.70E-03	7.06E-04	1.99E-07	4.35E-09	1.39E-10	7.54E-09
50	6.57E-03	2.45E-05	1.94E-03	1.38E-04	1.73E-05	6.06E-07	4.41E-07	2.26E-04	2.70E-03	7.84E-04	4.06E-07	9.16E-09	2.59E-10	1.45E-08
55	7.48E-03	3.21E-05	2.58E-03	1.84E-04	2.28E-05	8.38E-07	5.83E-07	3.01E-04	2.70E-03	8.53E-04	8.08E-07	1.85E-08	5.56E-10	3.03E-08
60	8.78E-03	4.31E-05	3.42E-03	2.47E-04	3.10E-05	1.15E-06	7.81E-07	3.99E-04	2.70E-03	9.35E-04	1.67E-06	4.34E-08	1.23E-09	6.47E-08
65	1.05E-02	5.75E-05	4.59E-03	3.27E-04	4.31E-05	1.53E-06	1.05E-06	5.31E-04	2.71E-03	1.01E-03	3.97E-06	9.24E-08	2.46E-09	1.33E-07
70	1.29E-02	7.88E-05	6.33E-03	4.42E-04	6.00E-05	2.11E-06	1.41E-06	7.33E-04	2.71E-03	1.11E-03	9.31E-06	1.97E-07	4.89E-09	2.64E-07
75	1.59E-02	1.08E-04	8.32E-03	6.09E-04	8.47E-05	2.99E-06	1.93E-06	9.57E-04	2.73E-03	1.21E-03	2.09E-05	4.65E-07	1.04E-08	5.99E-07
80	2.14E-02	1.50E-04	1.21E-02	8.67E-04	1.23E-04	4.35E-06	2.72E-06	1.41E-03	2.78E-03	1.32E-03	4.71E-05	1.11E-06	2.41E-08	1.51E-06
85	2.92E-02	2.35E-04	1.83E-02	1.33E-03	1.93E-04	6.47E-06	4.28E-06	2.14E-03	2.92E-03	1.47E-03	1.33E-04	3.22E-06	5.48E-08	3.92E-06
90	4.45E-02	3.85E-04	3.02E-02	2.17E-03	3.29E-04	1.14E-05	6.98E-06	3.49E-03	3.36E-03	1.68E-03	4.43E-04	1.08E-05	1.83E-07	1.23E-05
95	8.61E-02	8.32E-04	6.44E-02	4.92E-03	7.36E-04	2.69E-05	1.48E-05	7.39E-03	5.39E-03	2.04E-03	1.87E-03	5.26E-05	7.26E-07	4.91E-05
max	7.50E+00	3.48E-02	6.31E+00	3.86E-01	4.12E-02	3.54E-03	6.03E-04	7.50E-01	1.19E-01	1.38E-02	9.77E-02	4.65E-03	2.58E-05	2.22E-03
mean	2.62E-02	2.01E-04	1.76E-02	1.29E-03	2.03E-04	7.90E-06	3.63E-06	2.06E-03	3.36E-03	8.48E-04	5.65E-04	1.59E-05	2.05E-07	1.20E-05
95/50	1.31E+01	3.40E+01	3.32E+01	3.57E+01	4.26E+01	4.44E+01	3.36E+01	3.27E+01	2.00E+00	2.61E+00	4.59E+03	5.74E+03	2.80E+03	3.40E+03
95 - 50	7.95E-02	8.08E-04	6.24E-02	4.78E-03	7.18E-04	2.63E-05	1.44E-05	7.17E-03	2.69E-03	1.26E-03	1.87E-03	5.26E-05	7.26E-07	4.91E-05

[a] Dose directly from primary contamination and air transport.

Note: Any pathway with 50th or 95th percentile dose that is more than 5 percent of the 50th or 95th percentile dose from all pathways, respectively was considered significant in this analysis and is highlighted. Different colors are used in different rows.

Table B-64 Distributions of Peak Total Dose and Peak Pathway Dose Obtained with Probabilistic Calculations for Offsite Resident via Air Transport Scenario Concerning Pu-239 Contamination (mrem/yr per pCi/g)

Percentile	Peak total dose	Water release							CZ and air[a]					
		External ground	Fish ingestion	Plant ingestion	Meat ingestion	Milk ingestion	Soil Ingestion	Water ingestion	External ground	Inhalation	Plant ingestion	Meat ingestion	Milk ingestion	Soil ingestion
5	5.75E-04	1.23E-10	3.20E-05	2.35E-06	3.27E-11	1.17E-09	2.27E-08	4.72E-06	5.66E-07	1.02E-05	1.01E-12	5.94E-17	3.11E-16	1.93E-11
10	1.29E-03	3.19E-10	8.13E-05	5.70E-06	1.57E-10	2.86E-09	5.74E-08	1.20E-05	5.66E-07	4.86E-05	7.68E-11	1.66E-15	7.40E-15	1.05E-10
15	1.83E-03	5.92E-10	1.55E-04	1.12E-05	3.96E-10	5.42E-09	1.11E-07	2.28E-05	5.66E-07	1.67E-04	5.30E-10	1.09E-14	4.28E-14	3.95E-10
20	2.26E-03	1.01E-09	2.65E-04	1.95E-05	8.49E-10	9.33E-09	1.83E-07	3.87E-05	5.66E-07	4.40E-04	2.54E-09	4.91E-14	1.60E-13	1.05E-09
25	2.71E-03	1.61E-09	4.07E-04	3.02E-05	1.69E-09	1.49E-08	2.94E-07	5.97E-05	5.66E-07	8.03E-04	7.94E-09	1.51E-13	4.48E-13	2.56E-09
30	3.15E-03	2.45E-09	6.17E-04	4.50E-05	3.02E-09	2.25E-08	4.51E-07	9.03E-05	5.66E-07	1.09E-03	2.07E-08	4.83E-13	1.09E-12	5.09E-09
35	3.66E-03	3.44E-09	8.83E-04	6.40E-05	5.11E-09	3.23E-08	6.43E-07	1.30E-04	5.66E-07	1.34E-03	4.51E-08	1.18E-12	2.28E-12	1.01E-08
40	4.21E-03	4.70E-09	1.21E-03	8.93E-05	8.86E-09	4.50E-08	8.85E-07	1.77E-04	5.66E-07	1.55E-03	9.62E-08	2.95E-12	4.87E-12	2.13E-08
45	4.86E-03	6.56E-09	1.64E-03	1.22E-04	1.48E-08	6.09E-08	1.21E-06	2.40E-04	5.66E-07	1.75E-03	2.09E-07	7.29E-12	1.11E-11	4.24E-08
50	5.65E-03	8.88E-09	2.21E-03	1.64E-04	2.47E-08	8.21E-08	1.65E-06	3.24E-04	5.66E-07	1.93E-03	4.23E-07	1.68E-11	2.26E-11	8.61E-08
55	6.75E-03	1.20E-08	2.98E-03	2.27E-04	4.15E-08	1.11E-07	2.23E-06	4.37E-04	5.66E-07	2.13E-03	9.36E-07	3.80E-11	4.96E-11	1.81E-07
60	8.16E-03	1.59E-08	4.01E-03	3.06E-04	7.09E-08	1.48E-07	3.00E-06	5.90E-04	5.66E-07	2.30E-03	2.26E-06	9.37E-11	1.15E-10	3.48E-07
65	9.99E-03	2.19E-08	5.44E-03	4.06E-04	1.16E-07	2.03E-07	4.12E-06	7.92E-04	5.68E-07	2.50E-03	4.57E-06	2.27E-10	2.53E-10	7.32E-07
70	1.29E-02	2.89E-08	7.41E-03	5.59E-04	1.92E-07	2.81E-07	5.48E-06	1.09E-03	5.71E-07	2.73E-03	9.81E-06	5.55E-10	5.39E-10	1.43E-06
75	1.67E-02	4.10E-08	1.03E-02	7.66E-04	3.56E-07	4.07E-07	7.72E-06	1.52E-03	5.80E-07	2.99E-03	2.22E-05	1.46E-09	1.19E-09	3.17E-06
80	2.25E-02	5.90E-08	1.49E-02	1.09E-03	6.79E-07	5.79E-07	1.10E-05	2.16E-03	6.08E-07	3.32E-03	5.67E-05	4.22E-09	2.89E-09	8.78E-06
85	3.19E-02	8.91E-08	2.25E-02	1.68E-03	1.49E-06	9.07E-07	1.69E-05	3.33E-03	6.77E-07	3.70E-03	1.69E-04	1.30E-08	8.61E-09	2.29E-05
90	4.94E-02	1.52E-07	3.76E-02	2.79E-03	3.72E-06	1.52E-06	2.86E-05	5.52E-03	9.01E-07	4.26E-03	5.80E-04	5.42E-08	3.00E-08	7.08E-05
95	1.04E-01	3.25E-07	8.24E-02	6.08E-03	1.71E-05	3.59E-06	6.18E-05	1.17E-02	1.97E-06	5.34E-03	2.19E-03	3.68E-07	1.10E-07	2.97E-04
max	1.32E+01	1.55E-05	1.07E+01	8.39E-01	2.84E-02	7.12E-04	4.32E-03	1.64E+00	5.26E-05	5.34E-02	4.81E-02	3.20E-03	2.98E-06	1.14E-02
mean	3.06E-02	7.97E-08	2.26E-02	1.74E-03	2.32E-05	1.02E-06	1.57E-05	3.34E-03	9.18E-07	2.20E-03	5.54E-04	1.87E-06	3.11E-08	7.65E-05
95/50	1.84E+01	3.66E+01	3.72E+01	3.70E+01	6.94E+02	4.37E+01	3.74E+01	3.62E+01	3.48E+00	2.76E+00	5.17E+03	2.19E+04	4.88E+03	3.45E+03
95 - 50	9.85E-02	3.16E-07	8.02E-02	5.91E-03	1.71E-05	3.51E-06	6.01E-05	1.14E-02	1.40E-06	3.40E-03	2.19E-03	3.68E-07	1.10E-07	2.97E-04

[a] Dose directly from primary contamination and air transport.

Note: Any pathway with 50th or 95th percentile dose that is more than 5 percent of the 50th or 95th percentile dose from all pathways, respectively was considered significant in this analysis and is highlighted. Different colors are used in different rows.

Table B-65 Distributions of Peak Total Dose and Peak Pathway Dose Obtained with Probabilistic Calculations for Offsite Resident via Air Transport Scenario Concerning Ra-226 Contamination (mrem/yr per pCi/g)

Percentile	Peak total dose	Water release								CZ and air[a]						
		External ground	Fish ingestion	Radon	Plant ingestion	Meat ingestion	Milk ingestion	Soil ingestion	Water ingestion	External ground	Inhalation	Radon	Plant ingestion	Meat ingestion	Milk ingestion	Soil ingestion
5	7.58E-01	1.39E-06	1.65E-02	2.42E-07	9.82E-05	5.66E-05	1.13E-05	1.93E-07	2.01E-04	2.75E-02	1.08E-04	3.88E-01	1.34E-07	1.26E-08	1.71E-09	1.83E-09
10	1.02E+00	4.34E-06	3.97E-02	8.17E-07	2.35E-04	1.31E-04	2.67E-05	4.60E-07	4.72E-04	2.75E-02	1.43E-04	5.39E-01	3.11E-07	3.04E-08	3.88E-09	7.70E-09
15	1.29E+00	9.13E-06	7.70E-02	1.83E-06	4.44E-04	2.48E-04	5.00E-05	9.09E-07	9.33E-04	2.75E-02	1.67E-04	6.43E-01	6.94E-07	5.99E-08	8.03E-09	2.14E-08
20	1.52E+00	1.65E-05	1.21E-01	3.33E-06	7.18E-04	4.05E-04	8.17E-05	1.52E-06	1.44E-03	2.75E-02	1.91E-04	7.60E-01	1.36E-06	1.10E-07	1.68E-08	4.53E-08
25	1.75E+00	2.72E-05	1.87E-01	5.87E-06	1.11E-03	6.14E-04	1.24E-04	2.47E-06	2.22E-03	2.75E-02	2.14E-04	8.55E-01	2.85E-06	2.37E-07	3.52E-08	8.89E-08
30	1.96E+00	4.36E-05	2.73E-01	9.39E-06	1.64E-03	9.02E-04	1.85E-04	3.62E-06	3.26E-03	2.75E-02	2.37E-04	9.74E-01	5.30E-06	4.79E-07	6.61E-08	1.85E-07
35	2.24E+00	6.47E-05	3.85E-01	1.48E-05	2.34E-03	1.28E-03	2.65E-04	5.30E-06	4.60E-03	2.75E-02	2.58E-04	1.09E+00	1.05E-05	9.31E-07	1.26E-07	3.66E-07
40	2.54E+00	9.43E-05	5.41E-01	2.23E-05	3.22E-03	1.78E-03	3.63E-04	7.29E-06	6.43E-03	2.75E-02	2.79E-04	1.21E+00	2.15E-05	1.83E-06	2.45E-07	7.36E-07
45	2.83E+00	1.38E-04	7.45E-01	3.33E-05	4.42E-03	2.43E-03	4.88E-04	1.01E-05	8.81E-03	2.75E-02	2.99E-04	1.34E+00	4.16E-05	3.65E-06	5.08E-07	1.45E-06
50	3.15E+00	1.86E-04	1.01E+00	4.78E-05	5.98E-03	3.36E-03	6.78E-04	1.37E-05	1.19E-02	2.75E-02	3.24E-04	1.45E+00	8.26E-05	7.31E-06	1.02E-06	2.86E-06
55	3.62E+00	2.62E-04	1.35E+00	6.73E-05	8.20E-03	4.56E-03	9.21E-04	1.87E-05	1.61E-02	2.75E-02	3.49E-04	1.58E+00	1.68E-04	1.43E-05	2.00E-06	5.41E-06
60	4.05E+00	3.58E-04	1.88E+00	9.64E-05	1.11E-02	6.07E-03	1.25E-03	2.47E-05	2.22E-02	2.75E-02	3.77E-04	1.72E+00	3.20E-04	2.96E-05	4.19E-06	1.13E-05
65	4.71E+00	4.99E-04	2.53E+00	1.38E-04	1.50E-02	8.51E-03	1.70E-03	3.44E-05	3.01E-02	2.75E-02	4.07E-04	1.87E+00	6.64E-04	6.21E-05	8.31E-06	2.26E-05
70	5.49E+00	7.23E-04	3.46E+00	2.08E-04	2.07E-02	1.13E-02	2.32E-03	4.70E-05	4.06E-02	2.75E-02	4.39E-04	2.06E+00	1.35E-03	1.16E-04	1.63E-05	4.52E-05
75	6.76E+00	1.02E-03	4.81E+00	3.19E-04	2.83E-02	1.60E-02	3.24E-03	6.71E-05	5.73E-02	2.75E-02	4.77E-04	2.29E+00	2.70E-03	2.37E-04	3.23E-05	1.03E-04
80	8.88E+00	1.52E-03	6.97E+00	5.02E-04	4.04E-02	2.33E-02	4.75E-03	9.54E-05	8.17E-02	2.78E-02	5.21E-04	2.53E+00	5.62E-03	4.66E-04	6.64E-05	2.27E-04
85	1.25E+01	2.41E-03	1.07E+01	8.18E-04	6.40E-02	3.47E-02	7.13E-03	1.47E-04	1.26E-01	3.09E-02	5.86E-04	2.83E+00	1.09E-02	9.60E-04	1.37E-04	5.67E-04
90	2.03E+01	4.27E-03	1.80E+01	1.68E-03	1.08E-01	6.21E-02	1.26E-02	2.58E-04	2.13E-01	4.18E-02	6.83E-04	3.26E+00	2.25E-02	1.88E-03	2.71E-04	1.41E-03
95	4.18E+01	9.44E-03	3.93E+01	4.10E-03	2.37E-01	1.36E-01	2.77E-02	5.65E-04	4.60E-01	8.72E-02	8.51E-04	3.91E+00	5.35E-02	4.23E-03	6.50E-04	4.13E-03
max	1.37E+03	5.31E-01	1.34E+03	6.40E-01	7.76E+00	3.73E+00	7.05E-01	5.36E-02	1.53E+01	2.32E+00	1.42E-02	1.03E+01	2.26E+00	1.15E-01	1.10E-02	1.54E-01
mean	1.18E+01	2.39E-03	9.91E+00	1.40E-03	5.90E-02	3.36E-02	6.80E-03	1.47E-04	1.16E-01	4.25E-02	3.96E-04	1.71E+00	1.29E-02	8.63E-04	1.31E-04	1.02E-03
95/50	1.33E+01	5.07E+01	3.91E+01	8.58E+01	3.97E+01	4.05E+01	4.08E+01	4.13E+01	3.85E+01	3.17E+00	2.63E+00	2.70E+00	6.47E+02	5.79E+02	6.34E+02	1.44E+03
95 - 50	3.86E+01	9.25E-03	3.83E+01	4.06E-03	2.31E-01	1.33E-01	2.70E-02	5.51E-04	4.49E-01	5.98E-02	5.27E-04	2.46E+00	5.34E-02	4.22E-03	6.49E-04	4.12E-03

[a] Dose directly from primary contamination and air transport.

Note: Any pathway with 50th or 95th percentile dose that is more than 5 percent of the 50th or 95th percentile dose from all pathways, respectively was considered significant in this analysis and is highlighted. Different colors are used in different rows.

Table B-66 Distributions of Peak Total Dose and Peak Pathway Dose Obtained with Probabilistic Calculations for Offsite Resident via Air Transport Scenario Concerning Ra-228 Contamination (mrem/yr per pCi/g)

Percentile	Peak total dose	Water release								CZ and air[a]						
		External ground	Fish ingestion	Radon	Plant ingestion	Meat ingestion	Milk ingestion	Soil ingestion	Water ingestion	External ground	Inhalation	Radon	Plant ingestion	Meat ingestion	Milk ingestion	Soil ingestion
5	5.59E-01	1.24E-07	4.27E-05	4.22E-09	2.91E-06	2.15E-07	1.35E-07	1.33E-09	6.51E-06	2.33E-02	6.75E-05	5.07E-01	2.17E-09	2.24E-11	3.99E-12	2.07E-11
10	6.43E-01	2.99E-07	1.17E-04	9.81E-09	7.97E-06	5.94E-07	4.95E-07	3.60E-09	1.62E-05	2.33E-02	1.82E-04	5.93E-01	1.35E-08	1.29E-10	2.97E-11	9.35E-11
15	7.09E-01	5.44E-07	2.43E-04	1.83E-08	1.56E-05	1.25E-06	1.06E-06	7.29E-09	3.10E-05	2.33E-02	2.47E-04	6.50E-01	4.05E-08	4.27E-10	1.15E-10	2.43E-10
20	7.63E-01	9.72E-07	4.37E-04	3.10E-08	2.71E-05	2.23E-06	1.99E-06	1.24E-08	5.40E-05	2.33E-02	2.98E-04	7.07E-01	9.31E-08	1.14E-09	3.46E-10	6.08E-10
25	8.17E-01	1.51E-06	6.79E-04	4.88E-08	4.21E-05	3.64E-06	3.39E-06	2.02E-08	8.74E-05	2.33E-02	3.42E-04	7.55E-01	2.08E-07	2.73E-09	9.31E-10	1.24E-09
30	8.66E-01	2.25E-06	1.05E-03	6.97E-08	6.23E-05	5.44E-06	5.57E-06	3.07E-08	1.24E-04	2.33E-02	3.82E-04	8.05E-01	4.05E-07	5.61E-09	2.05E-09	2.39E-09
35	9.11E-01	3.16E-06	1.51E-03	9.97E-08	9.35E-05	8.26E-06	8.42E-06	4.52E-08	1.84E-04	2.33E-02	4.26E-04	8.49E-01	7.63E-07	1.10E-08	4.29E-09	4.75E-09
40	9.55E-01	4.55E-06	2.25E-03	1.39E-07	1.32E-04	1.28E-05	1.31E-05	6.48E-08	2.60E-04	2.33E-02	4.72E-04	8.91E-01	1.53E-06	2.11E-08	9.03E-09	9.54E-09
45	1.00E+00	6.18E-06	3.17E-03	1.83E-07	1.80E-04	1.76E-05	1.96E-05	9.36E-08	3.59E-04	2.33E-02	5.17E-04	9.35E-01	3.09E-06	4.48E-08	2.01E-08	1.85E-08
50	1.05E+00	8.24E-06	4.41E-03	2.51E-07	2.45E-04	2.45E-05	2.76E-05	1.28E-07	4.88E-04	2.33E-02	5.59E-04	9.76E-01	6.45E-06	8.93E-08	4.05E-08	3.69E-08
55	1.09E+00	1.10E-05	6.17E-03	3.36E-07	3.39E-04	3.47E-05	4.06E-05	1.73E-07	6.62E-04	2.33E-02	6.05E-04	1.02E+00	1.26E-05	1.92E-07	7.96E-08	7.04E-08
60	1.15E+00	1.47E-05	8.71E-03	4.46E-07	4.68E-04	5.00E-05	5.96E-05	2.38E-07	8.92E-04	2.33E-02	6.51E-04	1.07E+00	2.55E-05	3.75E-07	1.75E-07	1.40E-07
65	1.20E+00	2.04E-05	1.25E-02	5.96E-07	6.49E-04	7.13E-05	8.61E-05	3.38E-07	1.26E-03	2.33E-02	7.01E-04	1.13E+00	5.45E-05	7.70E-07	3.47E-07	3.04E-07
70	1.26E+00	2.81E-05	1.85E-02	8.00E-07	9.05E-04	1.01E-04	1.30E-04	4.95E-07	1.84E-03	2.33E-02	7.63E-04	1.18E+00	1.13E-04	1.59E-06	7.09E-07	6.36E-07
75	1.33E+00	3.94E-05	2.67E-02	1.09E-06	1.36E-03	1.52E-04	1.98E-04	6.92E-07	2.58E-03	2.34E-02	8.29E-04	1.24E+00	2.34E-04	3.36E-06	1.62E-06	1.34E-06
80	1.40E+00	5.74E-05	4.01E-02	1.52E-06	1.98E-03	2.43E-04	3.09E-04	1.04E-06	3.86E-03	2.34E-02	9.04E-04	1.30E+00	5.25E-04	7.72E-06	3.94E-06	2.93E-06
85	1.49E+00	9.05E-05	6.39E-02	2.31E-06	3.01E-03	4.01E-04	5.14E-04	1.68E-06	5.86E-03	2.36E-02	1.01E-03	1.39E+00	1.33E-03	1.93E-05	1.05E-05	7.61E-06
90	1.61E+00	1.58E-04	1.22E-01	3.92E-06	5.35E-03	7.60E-04	9.78E-04	3.15E-06	1.06E-02	2.39E-02	1.15E-03	1.50E+00	3.78E-03	6.38E-05	4.08E-05	1.92E-05
95	1.82E+00	3.33E-04	2.88E-01	8.44E-06	1.24E-02	1.88E-03	2.50E-03	7.31E-06	2.52E-02	2.54E-02	1.38E-03	1.66E+00	1.33E-02	2.48E-04	2.05E-04	6.87E-05
max	1.17E+02	3.34E-02	1.01E+02	4.46E-04	4.32E+00	9.43E-01	1.47E+00	1.21E-03	8.22E+00	1.09E-01	3.32E-03	2.33E+00	9.62E-01	2.20E-02	1.37E-02	3.92E-03
mean	1.14E+00	9.92E-05	9.61E-02	2.20E-06	4.30E-03	7.17E-04	1.15E-03	2.21E-06	8.21E-03	2.39E-02	6.25E-04	1.02E+00	3.36E-03	8.27E-05	5.74E-05	1.90E-05
95/50	1.73E+00	4.04E+01	6.53E+01	3.37E+01	5.07E+01	7.70E+01	9.05E+01	5.72E+01	5.16E+01	1.09E+00	2.46E+00	1.70E+00	2.06E+03	2.78E+03	5.06E+03	1.86E+03
95 - 50	7.68E-01	3.25E-04	2.83E-01	8.19E-06	1.22E-02	1.86E-03	2.47E-03	7.19E-06	2.47E-02	2.06E-03	8.18E-04	6.80E-01	1.33E-02	2.48E-04	2.05E-04	6.87E-05

[a] Dose directly from primary contamination and air transport.

Note: Any pathway with 50th or 95th percentile dose that is more than 5 percent of the 50th or 95th percentile dose from all pathways, respectively was considered significant in this analysis and is highlighted. Different colors are used in different rows.

Table B-67 Distributions of Peak Total Dose and Peak Pathway Dose Obtained with Probabilistic Calculations for Offsite Resident via Air Transport Scenario Concerning Sr-90 Contamination (mrem/yr per pCi/g)

Percentile	Peak total dose	Water release							CZ and air[a]					
		External ground	Fish ingestion	Plant ingestion	Meat ingestion	Milk ingestion	Soil ingestion	Water ingestion	External ground	Inhalation	Plant ingestion	Meat ingestion	Milk ingestion	Soil ingestion
5	1.17E-04	4.36E-09	3.42E-07	7.70E-07	7.78E-08	2.81E-07	6.56E-10	1.01E-06	1.13E-04	3.55E-09	3.21E-14	6.91E-18	1.96E-18	3.35E-13
10	1.21E-04	1.02E-08	7.92E-07	1.85E-06	1.96E-07	7.16E-07	1.52E-09	2.34E-06	1.13E-04	1.92E-08	5.16E-11	3.29E-13	2.87E-13	1.84E-12
15	1.27E-04	1.85E-08	1.50E-06	3.65E-06	3.77E-07	1.42E-06	2.71E-09	4.43E-06	1.13E-04	1.03E-07	3.74E-10	6.25E-12	5.45E-12	6.71E-12
20	1.39E-04	3.09E-08	2.47E-06	6.02E-06	6.80E-07	2.28E-06	4.57E-09	7.28E-06	1.13E-04	3.84E-07	1.60E-09	3.00E-11	3.00E-11	1.81E-11
25	1.54E-04	4.99E-08	3.91E-06	9.10E-06	1.02E-06	3.62E-06	7.41E-09	1.14E-05	1.13E-04	9.01E-07	5.24E-09	1.05E-10	1.05E-10	4.11E-11
30	1.74E-04	7.43E-08	5.87E-06	1.36E-05	1.56E-06	5.42E-06	1.11E-08	1.71E-05	1.13E-04	1.37E-06	1.38E-08	2.95E-10	2.91E-10	9.02E-11
35	2.00E-04	1.02E-07	8.10E-06	1.96E-05	2.26E-06	7.72E-06	1.52E-08	2.41E-05	1.13E-04	1.73E-06	2.94E-08	6.94E-10	6.38E-10	1.88E-10
40	2.40E-04	1.43E-07	1.11E-05	2.80E-05	3.19E-06	1.07E-05	2.13E-08	3.23E-05	1.13E-04	2.01E-06	6.59E-08	1.54E-09	1.48E-09	3.54E-10
45	2.87E-04	1.96E-07	1.53E-05	3.81E-05	4.34E-06	1.47E-05	2.91E-08	4.50E-05	1.13E-04	2.27E-06	1.33E-07	3.54E-09	3.24E-09	6.87E-10
50	3.47E-04	2.66E-07	2.08E-05	5.13E-05	6.15E-06	1.93E-05	3.97E-08	6.07E-05	1.13E-04	2.52E-06	2.80E-07	7.71E-09	7.22E-09	1.35E-09
55	4.34E-04	3.57E-07	2.78E-05	6.86E-05	8.85E-06	2.60E-05	5.34E-08	8.08E-05	1.13E-04	2.75E-06	6.13E-07	1.72E-08	1.58E-08	2.85E-09
60	5.48E-04	4.78E-07	3.71E-05	9.08E-05	1.21E-05	3.65E-05	7.11E-08	1.07E-04	1.13E-04	2.99E-06	1.39E-06	3.29E-08	3.22E-08	5.91E-09
65	6.94E-04	6.35E-07	4.93E-05	1.26E-04	1.67E-05	4.97E-05	9.38E-08	1.45E-04	1.13E-04	3.23E-06	3.13E-06	6.85E-08	6.96E-08	1.14E-08
70	9.07E-04	8.72E-07	6.78E-05	1.69E-04	2.36E-05	6.77E-05	1.31E-07	1.98E-04	1.13E-04	3.50E-06	6.20E-06	1.64E-07	1.60E-07	2.36E-08
75	1.21E-03	1.17E-06	9.02E-05	2.43E-04	3.52E-05	9.32E-05	1.77E-07	2.66E-04	1.13E-04	3.81E-06	1.52E-05	4.04E-07	3.93E-07	5.43E-08
80	1.71E-03	1.66E-06	1.30E-04	3.54E-04	5.36E-05	1.36E-04	2.46E-07	3.77E-04	1.13E-04	4.19E-06	4.08E-05	1.17E-06	9.71E-07	1.35E-07
85	2.53E-03	2.52E-06	1.91E-04	5.27E-04	8.24E-05	2.04E-04	3.76E-07	5.62E-04	1.13E-04	4.65E-06	1.23E-04	3.25E-06	3.14E-06	3.54E-07
90	4.17E-03	4.24E-06	3.29E-04	8.55E-04	1.51E-04	3.38E-04	6.42E-07	9.52E-04	1.13E-04	5.30E-06	3.87E-04	1.07E-05	1.06E-05	1.07E-06
95	9.01E-03	9.44E-06	7.23E-04	2.00E-03	3.84E-04	7.89E-04	1.41E-06	2.00E-03	1.14E-04	6.42E-06	1.78E-03	5.24E-05	4.06E-05	4.94E-06
max	5.68E-01	5.65E-04	7.72E-02	1.27E-01	3.66E-02	9.76E-02	8.15E-05	2.32E-01	1.06E-03	1.37E-05	1.94E-01	1.38E-02	3.51E-03	2.14E-04
mean	2.39E-03	2.47E-06	2.01E-04	5.74E-04	1.18E-04	2.34E-04	3.72E-07	5.69E-04	1.18E-04	2.64E-06	6.67E-04	3.78E-05	1.51E-05	1.27E-06
95/50	2.59E+01	3.55E+01	3.48E+01	3.90E+01	6.24E+01	4.08E+01	3.55E+01	3.30E+01	1.01E+00	2.55E+00	6.36E+03	6.79E+03	5.62E+03	3.66E+03
95 - 50	8.66E-03	9.18E-06	7.02E-04	1.95E-03	3.78E-04	7.70E-04	1.37E-06	1.94E-03	1.55E-06	3.90E-06	1.78E-03	5.23E-05	4.06E-05	4.94E-06

[a] Dose directly from primary contamination and air transport.

Note: Any pathway with 50th or 95th percentile dose that is more than 5 percent of the 50th or 95th percentile dose from all pathways, respectively was considered significant in this analysis and is highlighted. Different colors are used in different rows.

Table B-68 Distributions of Peak Total Dose and Peak Pathway Dose Obtained with Probabilistic Calculations for Offsite Resident via Air Transport Scenario Concerning Tc-99 Contamination (mrem/yr per pCi/g)

Percentile	Peak total dose	Water release							CZ and air[a]					
		External ground	Fish ingestion	Plant ingestion	Meat ingestion	Milk ingestion	Soil ingestion	Water ingestion	External ground	Inhalation	Plant ingestion	Meat ingestion	Milk ingestion	Soil ingestion
5	6.40E-07	6.87E-13	4.79E-09	3.17E-08	3.70E-10	1.00E-08	9.56E-13	4.03E-08	2.72E-07	8.71E-11	1.23E-15	3.26E-20	9.97E-20	3.45E-16
10	9.31E-07	1.84E-12	1.37E-08	8.97E-08	1.03E-09	2.85E-08	2.54E-12	1.08E-07	2.72E-07	9.42E-10	1.28E-12	1.44E-15	1.06E-14	1.72E-15
15	1.31E-06	3.50E-12	2.67E-08	1.78E-07	2.24E-09	5.37E-08	4.90E-12	2.09E-07	2.72E-07	6.21E-09	8.20E-12	1.90E-14	1.61E-13	5.84E-15
20	1.86E-06	6.33E-12	4.76E-08	3.09E-07	3.69E-09	9.90E-08	8.77E-12	3.80E-07	2.72E-07	2.86E-08	2.88E-11	7.69E-14	7.67E-13	1.53E-14
25	2.58E-06	9.98E-12	7.77E-08	4.95E-07	6.00E-09	1.56E-07	1.39E-11	5.94E-07	2.72E-07	7.44E-08	9.01E-11	2.53E-13	2.29E-12	3.52E-14
30	3.70E-06	1.49E-11	1.20E-07	7.35E-07	9.03E-09	2.48E-07	2.09E-11	8.91E-07	2.72E-07	1.16E-07	2.34E-10	6.99E-13	6.42E-12	6.86E-14
35	5.26E-06	2.23E-11	1.77E-07	1.08E-06	1.34E-08	3.71E-07	3.15E-11	1.33E-06	2.72E-07	1.47E-07	5.44E-10	1.68E-12	1.42E-11	1.42E-13
40	7.33E-06	3.22E-11	2.58E-07	1.61E-06	1.97E-08	5.12E-07	4.49E-11	1.90E-06	2.72E-07	1.73E-07	1.15E-09	3.55E-12	3.21E-11	3.17E-13
45	1.02E-05	4.65E-11	3.61E-07	2.35E-06	2.81E-08	7.30E-07	6.47E-11	2.72E-06	2.72E-07	1.95E-07	2.43E-09	7.60E-12	7.73E-11	6.05E-13
50	1.37E-05	6.77E-11	5.17E-07	3.23E-06	4.02E-08	1.05E-06	9.45E-11	3.84E-06	2.72E-07	2.15E-07	4.93E-09	1.73E-11	1.71E-10	1.16E-12
55	1.87E-05	9.36E-11	7.57E-07	4.48E-06	5.77E-08	1.53E-06	1.30E-10	5.38E-06	2.72E-07	2.35E-07	1.10E-08	3.82E-11	3.80E-10	2.36E-12
60	2.49E-05	1.27E-10	1.07E-06	6.21E-06	7.99E-08	2.23E-06	1.79E-10	7.39E-06	2.72E-07	2.57E-07	2.47E-08	8.55E-11	8.43E-10	4.83E-12
65	3.61E-05	1.78E-10	1.58E-06	9.08E-06	1.16E-07	3.25E-06	2.49E-10	1.03E-05	2.72E-07	2.79E-07	5.46E-08	1.89E-10	1.86E-09	1.05E-11
70	5.15E-05	2.63E-10	2.36E-06	1.33E-05	1.71E-07	4.66E-06	3.71E-10	1.55E-05	2.72E-07	3.02E-07	1.28E-07	4.29E-10	4.36E-09	2.18E-11
75	7.68E-05	4.04E-10	3.66E-06	2.01E-05	2.62E-07	7.15E-06	5.75E-10	2.36E-05	2.72E-07	3.30E-07	2.96E-07	1.00E-09	9.94E-09	5.24E-11
80	1.17E-04	6.42E-10	5.92E-06	3.38E-05	4.35E-07	1.20E-05	8.90E-10	3.82E-05	2.72E-07	3.60E-07	7.35E-07	2.44E-09	2.48E-08	1.29E-10
85	1.94E-04	1.15E-09	1.01E-05	5.90E-05	7.99E-07	2.19E-05	1.63E-09	6.46E-05	2.72E-07	4.00E-07	2.29E-06	6.88E-09	6.46E-08	3.75E-10
90	3.70E-04	2.33E-09	2.17E-05	1.16E-04	1.63E-06	4.16E-05	3.20E-09	1.36E-04	2.73E-07	4.55E-07	7.91E-06	2.44E-08	2.38E-07	1.20E-09
95	8.86E-04	5.85E-09	5.72E-05	2.84E-04	4.13E-06	1.11E-04	8.06E-09	3.35E-04	2.75E-07	5.48E-07	3.56E-05	1.17E-07	1.12E-06	4.99E-09
Max	2.89E-02	1.84E-07	7.86E-03	1.38E-02	1.98E-04	5.79E-03	2.63E-07	1.03E-02	3.57E-07	1.19E-06	3.33E-03	1.34E-05	7.37E-05	1.27E-07
mean	2.03E-04	1.33E-09	1.91E-05	6.82E-05	1.06E-06	2.99E-05	1.89E-09	7.45E-05	2.73E-07	2.26E-07	1.11E-05	4.10E-08	3.26E-07	1.15E-09
95/50	6.47E+01	8.64E+01	1.11E+02	8.79E+01	1.03E+02	1.06E+02	8.53E+01	8.70E+01	1.01E+00	2.54E+00	7.22E+03	6.77E+03	6.53E+03	4.30E+03
95 - 50	8.72E-04	5.78E-09	5.67E-05	2.80E-04	4.09E-06	1.10E-04	7.97E-09	3.31E-04	3.24E-09	3.33E-07	3.56E-05	1.17E-07	1.12E-06	4.99E-09

[a] Dose directly from primary contamination and air transport.

Note: Any pathway with 50th or 95th percentile dose that is more than 5 percent of the 50th or 95th percentile dose from all pathways, respectively was considered significant in this analysis and is highlighted. Different colors are used in different rows.

Table B-69 Distributions of Peak Total Dose and Peak Pathway Dose Obtained with Probabilistic Calculations for Offsite Resident via Air Transport Scenario Concerning U-238 Contamination (mrem/yr per pCi/g)

Percentile	Peak total dose	Water release								CZ and air[a]						
		External ground	Fish ingestion	Radon	Plant ingestion	Meat ingestion	Milk ingestion	Soil ingestion	Water ingestion	External ground	Inhalation	Radon	Plant ingestion	Meat ingestion	Milk ingestion	Soil ingestion
5	4.92E-04	7.06E-08	5.41E-07	1.33E-13	5.49E-07	2.77E-08	2.71E-07	4.30E-09	1.04E-06	4.44E-04	6.76E-07	6.28E-10	1.91E-12	2.04E-14	8.24E-15	3.45E-12
10	5.51E-04	1.97E-07	1.42E-06	4.33E-13	1.40E-06	7.24E-08	8.08E-07	1.12E-08	2.73E-06	4.44E-04	3.03E-06	9.04E-10	2.65E-11	3.29E-13	4.87E-13	1.80E-11
15	5.90E-04	3.69E-07	2.68E-06	9.42E-13	2.71E-06	1.43E-07	1.68E-06	2.06E-08	5.09E-06	4.44E-04	1.02E-05	1.17E-09	1.54E-10	1.78E-12	5.56E-12	6.82E-11
20	6.28E-04	5.98E-07	4.48E-06	1.66E-12	4.28E-06	2.35E-07	3.02E-06	3.48E-08	8.32E-06	4.44E-04	2.70E-05	1.38E-09	5.61E-10	6.39E-12	2.74E-11	1.94E-10
25	6.63E-04	9.27E-07	6.63E-06	2.94E-12	6.60E-06	3.71E-07	4.84E-06	5.26E-08	1.29E-05	4.44E-04	5.75E-05	1.59E-09	1.88E-09	1.99E-11	9.75E-11	4.37E-10
30	6.99E-04	1.38E-06	9.80E-06	4.85E-12	9.82E-06	5.49E-07	7.54E-06	7.93E-08	1.89E-05	4.44E-04	7.93E-05	1.78E-09	4.79E-09	5.59E-11	2.90E-10	9.02E-10
35	7.43E-04	2.03E-06	1.47E-05	7.13E-12	1.42E-05	7.73E-07	1.11E-05	1.14E-07	2.82E-05	4.44E-04	9.59E-05	1.98E-09	1.05E-08	1.26E-10	6.96E-10	1.82E-09
40	7.95E-04	2.86E-06	2.09E-05	1.04E-11	2.02E-05	1.11E-06	1.60E-05	1.63E-07	3.98E-05	4.44E-04	1.11E-04	2.18E-09	2.20E-08	2.63E-10	1.61E-09	3.46E-09
45	8.60E-04	3.88E-06	2.91E-05	1.52E-11	2.82E-05	1.56E-06	2.27E-05	2.24E-07	5.59E-05	4.44E-04	1.24E-04	2.41E-09	4.46E-08	5.33E-10	3.67E-09	7.45E-09
50	9.46E-04	5.30E-06	3.87E-05	2.24E-11	3.88E-05	2.16E-06	3.12E-05	3.03E-07	7.53E-05	4.44E-04	1.38E-04	2.65E-09	9.78E-08	1.10E-09	7.65E-09	1.49E-08
55	1.05E-03	7.11E-06	5.26E-05	3.22E-11	5.25E-05	3.00E-06	4.39E-05	4.12E-07	9.88E-05	4.45E-04	1.51E-04	2.90E-09	2.21E-07	2.53E-09	1.67E-08	2.81E-08
60	1.18E-03	9.74E-06	7.08E-05	4.65E-11	6.88E-05	3.97E-06	6.19E-05	5.63E-07	1.35E-04	4.45E-04	1.65E-04	3.21E-09	4.58E-07	5.66E-09	3.83E-08	5.61E-08
65	1.38E-03	1.32E-05	9.56E-05	6.49E-11	9.34E-05	5.40E-06	9.13E-05	7.51E-07	1.81E-04	4.46E-04	1.79E-04	3.51E-09	9.70E-07	1.21E-08	8.06E-08	1.12E-07
70	1.63E-03	1.79E-05	1.30E-04	9.79E-11	1.26E-04	7.45E-06	1.28E-04	1.02E-06	2.45E-04	4.48E-04	1.96E-04	3.88E-09	2.03E-06	2.60E-08	1.86E-07	2.51E-07
75	2.04E-03	2.48E-05	1.82E-04	1.56E-10	1.79E-04	1.04E-05	1.92E-04	1.42E-06	3.46E-04	4.54E-04	2.13E-04	4.32E-09	4.89E-06	6.01E-08	4.34E-07	5.55E-07
80	2.61E-03	3.56E-05	2.56E-04	2.50E-10	2.63E-04	1.54E-05	2.99E-04	2.06E-06	4.86E-04	4.66E-04	2.36E-04	4.87E-09	1.17E-05	1.51E-07	1.12E-06	1.28E-06
85	3.62E-03	5.18E-05	3.79E-04	4.11E-10	3.85E-04	2.32E-05	4.77E-04	2.94E-06	7.24E-04	5.01E-04	2.65E-04	5.57E-09	3.28E-05	4.29E-07	3.11E-06	3.34E-06
90	5.56E-03	8.67E-05	6.60E-04	7.97E-10	6.43E-04	3.84E-05	8.66E-04	5.15E-06	1.22E-03	6.18E-04	3.04E-04	6.79E-09	9.79E-05	1.37E-06	9.44E-06	1.01E-05
95	1.23E-02	1.99E-04	1.50E-03	2.12E-09	1.46E-03	8.76E-05	2.28E-03	1.18E-05	2.65E-03	1.21E-03	3.80E-04	9.86E-09	4.63E-04	5.86E-06	4.15E-05	4.29E-05
Max	5.68E-01	1.01E-02	1.84E-01	2.18E-07	9.63E-02	1.00E-02	1.81E-01	5.95E-04	1.81E-01	2.69E-02	3.32E-03	2.54E-06	1.46E-02	2.05E-04	1.01E-02	1.56E-03
Mean	3.47E-03	4.97E-05	4.53E-04	7.70E-10	3.97E-04	2.76E-05	8.48E-04	2.90E-06	7.49E-04	6.36E-04	1.55E-04	7.68E-09	1.23E-04	1.71E-06	2.48E-05	1.14E-05
95/50	1.30E+01	3.76E+01	3.87E+01	9.47E+01	3.77E+01	4.06E+01	7.30E+01	3.91E+01	3.52E+01	2.71E+00	2.76E+00	3.72E+00	4.73E+03	5.31E+03	5.43E+03	2.88E+03
95 - 50	1.13E-02	1.94E-04	1.46E-03	2.10E-09	1.42E-03	8.54E-05	2.24E-03	1.15E-05	2.57E-03	7.62E-04	2.43E-04	7.21E-09	4.63E-04	5.86E-06	4.15E-05	4.29E-05

Dose directly from primary contamination and air transport.

Note: Any pathway with 50th or 95th percentile dose that is more than 5 percent of the 50th or 95th percentile dose from all pathways, respectively was considered significant in this analysis and is highlighted. Different colors are used in different rows.

Table B-70 Dominant Exposure Pathways at the 50th and 95th Dose Percentiles for Air Transport Scenario

Radionuclide	Table	Percentile		Comments
		50	95	
C-14	B-58	Fish (Water) Plant (CZ and air) Meat (CZ and air) Inhalation (CZ and air)	Fish (Water) Plant (CZ and air)	The absolute dose variability in the peak total dose is mainly associated with variability in fish ingestion pathway as shown in the last row in Table B-58.
Co-60	B-59	External (CZ and air)	External (CZ and air)	The peak total dose has small relative variability (i.e., ratio of peak dose at 95 percent to 50 percent is 1.02). The absolute dose variability in the peak total dose is mainly associated with variability in direct external exposure and plant ingestion from both water release and CZ and Air release, fish ingestion and water ingestion pathways from water release as shown in the last row in Table B-59.
Cs-137	B-60	External (CZ and air)	Fish (Water) External (CZ and air)	The absolute dose variability in the peak total dose is mainly associated with variability in fish ingestion, external exposure, and meat ingestion pathways related with water release as shown in the last row in Table B-60.
H-3	B-61	Inhalation (CZ and air)	Inhalation (CZ and air)	The absolute dose variability in the peak total dose is mainly associated with variability in inhalation pathway related with CZ and Air release as shown in the last row in Table B-61.
I-129	B-62	Milk (Water) Water (Water) Plant (Water) Meat (Water) Fish (Water)	Milk (Water) Water (Water) Plant (Water) Meat (Water) Fish (Water)	The absolute dose variability in the peak total dose is mainly associated with variability in milk ingestion, water ingestion, meat ingestion, plant ingestion, and fish ingestion; all pathways related with water release as shown in the last row in Table B-62.
Np-237	B-63	External (CZ and air) Inhalation (CZ and air) Fish (Water)	Fish (Water) Water (Water) Plant (Water) External (CZ and air)	The absolute dose variability in the peak total dose is mainly associated with variability in fish ingestion, water ingestion, and plant ingestion pathways related with water release as shown in the last row in Table B-63.
Pu-239	B-64	Inhalation (CZ and air) Fish (Water) Water (Water)	Fish (Water) Water (Water) Plant (Water) Inhalation (CZ and air)	The absolute dose variability in the peak total dose is mainly associated with variability in fish ingestion, water ingestion, and plant ingestion pathways related with water release as shown in the last row in Table B-64.
Ra-226	B-65	Radon (CZ and air) Fish (Water)	Fish (Water) Radon (CZ and air)	The absolute dose variability in the peak total dose is mainly associated with variability in fish ingestion and radon inhalation pathways as shown in the last row in Table B-65.
Ra-228	B-66	Radon (CZ and air)	Radon (CZ and air) Fish (Water)	The absolute dose variability in the peak total dose is mainly associated with variability in radon inhalation and fish ingestion pathways as shown in the last row in Table B-66.
Sr-90	B-67	External (CZ and air) Water (Water) Plant (Water) Fish (Water) Milk (Water)	Water (Water) Plant (Water) Plant (CZ and air) Fish (Water) Milk (Water)	The absolute dose variability in the peak total dose is mainly associated with variability in plant, water, milk, and fish ingestion related with water release and plant ingestion associated with CZ and air release as shown in the last row in Table B-67.
Tc-99	B-68	Water (Water) Plant (Water) Milk (Water)	Water (Water) Plant (Water) Fish (Water) Milk (Water)	The absolute dose variability in the peak total dose is mainly associated with variability in plant, milk, and water ingestion associated with water release as shown in the last row in Table B-68.
U-238	B-69	External (CZ and air) Inhalation (CZ and air) Water (Water)	External (CZ and air) Water (Water) Milk (Water) Plant (Water) Fish (Water)	The absolute dose variability in the peak total dose is mainly associated with variability in water ingestion, milk ingestion, fish ingestion, and plant ingestion associated with water release and external ground from CZ and air release as shown in the last row in Table B-69.

Note: any pathway with a peak dose that is more than 5 percent of the peak dose from all pathways is defined as a dominant exposure pathway.

Table B-71 Summary of Regression Analysis to Identify Parameters Influencing the Peak Total Dose for the Offsite Resident via Air Transport Scenario

C-14 Regression Coefficients for Peak All Pathways Dose			
Repetition =	1	2	3
Coefficient of determination (R-squared) =	0.75	0.77	0.76
Description of probabilistic variable	SRRC	SRRC	SRRC
Cover and management factor in area of primary contamination	0.44	0.44	0.44
Slope-length-steepness factor in area of primary contamination	0.38	0.38	0.35
Thickness of contaminated zone	0.34	0.36	0.36
Water to aquatic food transfer factor of C for fish	0.31	0.3	0.31
Dry bulk density of contaminated zone	0.22	0.23	0.24
Rainfall and runoff factor in area of primary contamination	0.23	0.22	0.22
Runoff coefficient of catchment area	-0.13	-0.13	-0.14
K_d of C-14 in bottom sediment in surface water body	-0.13	-0.12	-0.13
Soil erodibility factor of contaminated zone	0.12	0.11	0.1
C-14 evasion flux rate from soil	0.11	0.09	0.11
Thickness of evasion layer for C-14 in soil	0.09	0.09	0.12
Mass fraction of C-12 in atmosphere	-0.05	-0.06	-0.08
Mass fraction of C-12 in fruit, grain, non-leafy vegetables	0.03	0.03	0.06
Co-60 Regression Coefficients for Peak All Pathways Dose			
Repetition =	1	2	3
Coefficient of determination (R-squared) =	0.68	0.68	0.66
Description of probabilistic variable	SRRC	SRRC	SRRC
K_d of Co-60 in bottom sediment in surface water body	-0.43	-0.41	-0.4
Deposition velocity of all particulates (to compute atmospheric release)	0.38	0.39	0.4
Cover and management factor in area of primary contamination	0.37	0.35	0.38
Slope-length-steepness factor in area of primary contamination	0.32	0.31	0.28
Rainfall and runoff factor in area of primary contamination	0.17	0.19	0.17
Deposition velocity of all particulates of Co	0.17	0.17	0.16
Soil erodibility factor of contaminated zone	0.08	0.1	0.07
Mass loading of all particulates	0.08	0.08	0.08
Thickness of bottom sediment layer in adsorption/desorption equilibrium of radionuclides with water	-0.05	-0.07	-0.07
Cs-137 Regression Coefficients for Peak All Pathways Dose			
Repetition =	1	2	3
Coefficient of determination (R-squared) =	0.75	0.76	0.75
Description of probabilistic variable	SRRC	SRRC	SRRC

Note: For identifying parameters that impact the peak total dose, a cut-off value of 0.05 was subjectively selected for the SRRC.

Table B-71 Summary of Regression Analysis to Identify Parameters Influencing the Peak Total Dose for the Offsite Resident via Air Transport Scenario (cont.)

Cs-137 Regression Coefficients for Peak All Pathways Dose (cont.)			
Cover and management factor in area of primary contamination	0.47	0.45	0.47
K_d of Cs-137 in bottom sediment in surface water body	-0.45	-0.44	-0.42
Slope-length-steepness factor in area of primary contamination	0.38	0.39	0.38
Deposition velocity of all particulates (to compute atmospheric release)	0.23	0.23	0.26
Rainfall and runoff factor in area of primary contamination	0.19	0.23	0.2
Water to aquatic food transfer factor of Cs for Fish	0.19	0.17	0.2
Soil erodibility factor of contaminated zone	0.12	0.09	0.11
Thickness of bottom sediment layer in adsorption/desorption equilibrium of radionuclides with water	-0.09	-0.09	-0.08
Deposition velocity of all particulates of Cs	0.09	0.08	0.08
Density of bottom sediment	-0.06	-0.05	-0.03
Mass loading of all particulates	0.04	0.04	0.05
Intake to animal product transfer factor of Cs for Meat	0.03	0.04	0.05
H-3 Regression Coefficients for Peak All Pathways Dose			
Repetition =	1	2	3
Coefficient of Determination (R-squared) =	0.94	0.95	0.94
Description of probabilistic variable	SRC	SRC	SRC
Evapotranspiration coefficient in area of primary contamination	0.66	0.66	0.67
Runoff coefficient in area of primary contamination	-0.46	-0.47	-0.47
Dry bulk density of contaminated zone	0.32	0.32	0.32
Irrigation applied per year in area of primary contamination	0.27	0.27	0.27
K_d of H-3 in contaminated zone	-0.25	-0.26	-0.25
Thickness of contaminated zone	0.14	0.13	0.12
Total porosity of contaminated zone	-0.11	-0.11	-0.1
b parameter of contaminated zone	-0.08	-0.09	-0.09
I-129 Regression Coefficients for Peak All Pathways Dose			
Repetition =	1	2	3
Coefficient of determination (R-squared) =	0.74	0.76	0.74
Description of probabilistic variable	SRRC	SRRC	SRRC
Cover and management factor in area of primary contamination	0.57	0.55	0.56
Slope-length-steepness factor in area of primary contamination	0.45	0.47	0.46
Rainfall and runoff factor in area of primary contamination	0.28	0.3	0.26
Runoff coefficient of catchment area	-0.19	-0.18	-0.19
Soil erodibility factor of contaminated zone	0.13	0.13	0.13
Note: For identifying parameters that impact the peak total dose, a cut-off value of 0.05 was subjectively selected for the SRRC.			

Table B-71 Summary of Regression Analysis to Identify Parameters Influencing the Peak Total Dose for the Offsite Resident via Air Transport Scenario (cont.)

I-129 Regression Coefficients for Peak All Pathways Dose (cont.)			
Intake to animal product transfer factor of I for Milk	0.11	0.13	0.13
Deposition velocity of all particulates (to compute atmospheric release)	0.11	0.13	0.12
Hydraulic conductivity of saturated zone	0.07	0.08	0.1
Intake to animal product transfer factor of I for meat	0.07	0.1	0.07
Hydraulic gradient of saturated zone to surface waterbody	0.07	0.04	0.08
Irrigation applied per year (meters/year) to pasture and silage fields	0.04	0.07	0.06
K_d of I-129 in saturated zone	-0.04	-0.05	-0.05
Deposition velocity of all particulates of I	0.03	0.05	0.06
Np-237 Regression Coefficients for Peak All Pathways Dose			
Repetition =	1	2	3
Coefficient of determination (R-squared) =	0.77	0.77	0.75
Description of probabilistic variable	SRRC	SRRC	SRRC
Cover and management factor in area of primary contamination	0.58	0.58	0.57
Slope-length-steepness factor in area of primary contamination	0.47	0.48	0.46
Rainfall and runoff factor in area of primary contamination	0.28	0.27	0.26
Runoff coefficient of catchment area	-0.18	-0.18	-0.18
Deposition velocity of all particulates (to compute atmospheric release)	0.14	0.13	0.15
Soil erodibility factor of contaminated zone	0.14	0.12	0.14
Deposition velocity of respirable particulates of Np	-0.1	-0.13	-0.13
Mass loading of all particulates	0.11	0.11	0.13
Deposition velocity of all particulates of Np	0.04	0.04	0.05
K_d of Np-237 in bottom sediment in surface water body	-0.04	-0.05	-0.04
Support practice factor in area of primary contamination	0.05	0.03	0.03
Slope-length-steepness factor of catchment area	-0.02	-0.02	-0.05
Pu-239 Regression Coefficients for Peak All Pathways Dose			
Repetition =	1	2	3
Coefficient of determination (R-squared) =	0.76	0.74	0.75
Description of probabilistic variable	SRRC	SRRC	SRRC
Cover and management factor in area of primary contamination	0.55	0.54	0.55
Slope-length-steepness factor in area of primary contamination	0.47	0.46	0.45
Rainfall and runoff factor in area of primary contamination	0.22	0.23	0.22
Deposition velocity of respirable particulates of Pu	-0.18	-0.16	-0.18
Note: For identifying parameters that impact the peak total dose, a cut-off value of 0.05 was subjectively selected for the SRRC.			

**Table B-71	Summary of Regression Analysis to Identify Parameters Influencing the Peak Total Dose for the Offsite Resident via Air Transport Scenario (cont.)**

Pu-239 Regression Coefficients for Peak All Pathways Dose (cont.)			
Mass loading of all particulates	0.14	0.16	0.18
Runoff coefficient of catchment area	-0.15	-0.16	-0.15
Soil erodibility factor of contaminated zone	0.14	0.13	0.15
K_d of Pu-239 in bottom sediment in surface water body	-0.11	-0.13	-0.12
Slope-length-steepness factor of catchment area	-0.1	-0.12	-0.13
Cover and management factor of catchment area	-0.13	-0.1	-0.11
Deposition velocity of all particulates (to compute atmospheric release)	0.09	0.12	0.11
Deposition velocity of all particulates of Pu	0.04	0.05	0.04
Ra-226 Regression Coefficients for Peak All Pathways Dose			
Repetition =	1	2	3
Coefficient of determination (R-squared) =	0.77	0.77	0.76
Description of probabilistic variable	SRRC	SRRC	SRRC
Cover and management factor in area of primary contamination	0.52	0.51	0.5
Slope-length-steepness factor in area of primary contamination	0.43	0.44	0.43
Rn-222 emanation coefficient	0.26	0.27	0.27
Building air exchange rate	-0.22	-0.23	-0.22
Rainfall and runoff factor in area of primary contamination	0.19	0.19	0.18
Cover and management factor of catchment area	-0.2	-0.16	-0.17
Slope-length-steepness factor of catchment area	-0.14	-0.15	-0.19
Runoff coefficient of catchment area	-0.15	-0.16	-0.16
Soil erodibility factor of contaminated zone	0.15	0.12	0.14
Effective radon diffusion coefficient of contaminated zone	0.11	0.09	0.1
Dry bulk density of contaminated zone	0.07	0.08	0.1
K_d of Ra-226 in bottom sediment in surface water body	0.07	0.05	0.07
Thickness of contaminated zone	0.06	0.05	0.06
Soil erodibility factor (tons/acre) of catchment area	-0.05	-0.04	-0.06
Thickness of bottom sediment layer in adsorption/desorption equilibrium of radionuclides with water	0.04	0.04	0.05
Ra-228 Regression Coefficients for Peak All Pathways Dose			
Repetition =	1	2	3
Coefficient of determination (R-squared) =	0.87	0.87	0.88
Description of probabilistic variable	SRRC	SRRC	SRRC
Effective radon diffusion coefficient of contaminated zone	0.68	0.67	0.68
Note: For identifying parameters that impact the peak total dose, a cut-off value of 0.05 was subjectively selected for the SRRC.			

Table B-71 Summary of Regression Analysis to Identify Parameters Influencing the Peak Total Dose for the Offsite Resident via Air Transport Scenario (cont.)

Ra-228 Regression Coefficients for Peak All Pathways Dose (cont.)			
Rn-220 emanation coefficient	0.47	0.45	0.47
Dry bulk density of contaminated zone	0.39	0.39	0.4
Slope-length-steepness factor in area of primary contamination	0.12	0.12	0.12
K_d of Ra-228 in bottom sediment in surface water body	-0.09	-0.11	-0.09
Cover and management factor in area of primary contamination	0.1	0.08	0.09
Rainfall and runoff factor in area of primary contamination	0.05	0.05	0.04
Sr-90 Regression Coefficients for Peak All Pathways Dose			
Repetition =	1	2	3
Coefficient of determination (R-squared) =	0.72	0.74	0.73
Description of probabilistic variable	SRRC	SRRC	SRRC
Cover and management factor in area of primary contamination	0.55	0.56	0.56
Slope-length-steepness factor in area of primary contamination	0.44	0.46	0.43
Rainfall and runoff factor in area of primary contamination	0.26	0.27	0.25
Deposition velocity of all particulates (to compute atmospheric release)	0.23	0.22	0.24
Runoff coefficient of catchment area	-0.16	-0.16	-0.17
Soil erodibility factor of contaminated zone	0.13	0.1	0.13
Deposition velocity of all particulates of Sr	0.09	0.1	0.08
K_d of Sr-90 in bottom sediment in surface water body	-0.09	-0.07	-0.08
Soil to plant transfer factor of Sr for fruit, grain, non-leafy vegetables	0.09	0.05	0.08
Slope-length-steepness factor of catchment area	-0.03	-0.04	-0.05
Tc-99 Regression Coefficients for Peak All Pathways Dose			
Repetition =	1	2	3
Coefficient of determination (R-squared) =	0.62	0.61	0.6
Description of probabilistic variable	SRRC	SRRC	SRRC
Cover and management factor in area of primary contamination	0.4	0.38	0.37
Slope-length-steepness factor in area of primary contamination	0.34	0.33	0.34
Hydraulic conductivity of saturated zone	0.33	0.32	0.32
Hydraulic gradient of saturated zone to surface waterbody	0.26	0.22	0.27
Rainfall and runoff factor in area of primary contamination	0.19	0.21	0.19
Runoff coefficient of catchment area	-0.18	-0.18	-0.17
Deposition velocity of all particulates (to compute atmospheric release)	0.15	0.15	0.16
K_d of Tc-99 in saturated zone	-0.11	-0.13	-0.09
Note: For identifying parameters that impact the peak total dose, a cut-off value of 0.05 was subjectively selected for the SRRC.			

Table B-71 Summary of Regression Analysis to Identify Parameters Influencing the Peak Total Dose for the Offsite Resident via Air Transport Scenario (cont.)

Tc-99 Regression Coefficients for Peak All Pathways Dose (cont.)			
Soil erodibility factor of contaminated zone	0.08	0.06	0.09
Soil to plant transfer factor of Tc for fruit, grain, non-leafy vegetables	0.06	0.07	0.07
Deposition velocity of all particulates of Tc	0.06	0.04	0.06
Distance in the direction parallel to aquifer flow from downgradient edge of contamination	-0.05	-0.05	-0.04
U-238 Regression Coefficients for Peak All Pathways Dose			
Repetition =	1	2	3
Coefficient of determination (R-squared) =	0.7	0.69	0.69
Description of probabilistic variable	SRRC	SRRC	SRRC
Cover and management factor in area of primary contamination	0.52	0.49	0.5
Slope-length-steepness factor in area of primary contamination	0.4	0.43	0.42
Rainfall and runoff factor in area of primary contamination	0.23	0.23	0.23
Deposition velocity of all particulates (to compute atmospheric release)	0.18	0.19	0.2
Deposition velocity of respirable particulates of U	-0.16	-0.14	-0.16
Mass loading of all particulates	0.14	0.15	0.16
K_d of U-238 in bottom sediment in surface water body	-0.15	-0.14	-0.14
Runoff coefficient of catchment area	-0.15	-0.15	-0.13
Soil erodibility factor of contaminated zone	0.13	0.15	0.12
Intake to animal product transfer factor of U for Milk	0.08	0.09	0.12
Deposition velocity of all particulates of U	0.08	0.07	0.09
Cover and management factor of catchment area	-0.08	-0.06	-0.07
Slope-length-steepness factor of catchment area	-0.06	-0.04	-0.08
Note: For identifying parameters that impact the peak total dose, a cut-off value of 0.05 was subjectively selected for the SRRC.			

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APPENDIX C PARAMETER DISTRIBUTIONS FOR USE IN RESRAD-ONSITE, RESRAD-OFFSITE, AND RESRAD-BUILD COMPUTER CODES

C.1 Introduction

The selection for assignment of distribution follow the general rule developed for the RESRAD-ONSITE, RESRAD-BUILD, and RESRAD-OFFSITE parameter data collection efforts (Yu et al. 2000; Biwer et al. 2000, Yu et al. 2003; Yu et al. 2007). Some parameters used in the RESRAD-ONSITE and RESRAD-OFFSITE code have additional data available now; their parameter distributions are updated. Distribution for some new parameters is identified as significant and new parameters used in the RESRAD-OFFSITE code are developed.

For presentation, the parameters are grouped into six categories: soil and hydrogeological, meteorological, receptor characteristics, crops and livestock, building characteristics, and source characteristics. The presentation of each parameter distribution identifies the code or codes in which it is used and gives a brief description of the parameter and its units, assigned distributions, and input data.

C.2 Assignment of Parameter Distributions

Assignment of an appropriate distribution to an input parameter was primarily determined by the quantity of relevant data available. The distribution assigned each parameter was as specific as the data warranted. Documented distributions were used where available. However, data are often lacking for environmental exposure pathways. Some parameters have adequate data that follow a general trend, thus allowing assignment of a distribution. For some other parameters, data are too sparse to define a distribution. As fewer data become available, secondary types of information must be used in conjunction with the existing sample data. For each assignment in this task, supporting evidence and reasoning are presented in conjunction with any limitations so that the user can understand the relevance of the assigned distribution. A number of distributions are necessarily broad because of the generic nature of the building occupancy and residential farmer scenarios. The following subsections describe the methodology used as the amount of available data becomes more limited.

C.2.1 Parameters with Well-Characterized Distributions

Empirical distributions were available for some parameters within the context of the critical group or national average. For those parameters for which additional sampling was not expected to significantly change the distribution’s shape (i.e., the variability of the parameter is well represented), direct use of the statistical data was made. A user-specified continuous distribution was used as input to the Latin Hypercube Sampling (LHS) program.

C.2.2 Parameters with Sufficient Data

Sufficient relevant statistical data (data sets/matching function and parameter characteristics) were available for some parameters to clearly show a distribution type. If the use of an empirical distribution was not appropriate, the data were fit to the identified distribution. Goodness-of-fit may have been determined through the use of probability plots or other graphical representations.

C.2.3 Parameters with Some Data

Some parameters had some data available, but those data were not sufficient to define a distribution type. These parameters may have been assigned a distribution based on supporting information. If there was a mechanistic basis for assigning a given distribution to the data, such a distribution may have been used in the case of a sparse data set. In another case, surrogate data may have been used. If a distribution was well known for a parameter on a regional basis, the same distribution may have been used on a national basis. In either case, care must be taken to ensure that the existing data for the target scenario are complemented.

C.2.4 Parameters with Insufficient Data

In the case of a parameter for which a sufficient body of data was not available, an attempt was made to assign a distribution that fit a similar class of parameters or similar body of data. If an appropriate distribution was not found, a maximum entropy approach was used. In such a case, the distribution was restricted only by what was known.

Examples included the use of a uniform distribution if only potential lower and upper bounds were available (e.g., depth of roots, indoor dust filtration factor, runoff coefficient), or the use of a triangular distribution if a most likely value was known in addition to potential lower and upper bounds (i.e., depth of soil mixing layer, weathering removal constant).

C.2.5 Multiple Distributions

Some parameters can have more than one distribution assigned (e.g., hydraulic conductivity and total porosity can exhibit different distributions for different soil types).

C.3 Soil and Hydrogeological Parameter

C.3.1 Density of Soil

Applicable Codes: RESRAD-ONSITE and RESRAD-OFFSITE

Description: RESRAD-ONSITE uses the dry bulk density values for five distinct materials (cover layer, contaminated zone, unsaturated and saturated zones, and building foundation material). RESRAD-OFFSITE uses the dry bulk density for ten distinct areas (cover layer; contaminated zone; unsaturated and saturated zones; building foundation material; fruit, grain, nonleafy agriculture area; leafy vegetable agriculture area; pasture silage growing area; grain growing area; offsite dwelling area). The soil bulk, or dry, density is the ratio of the mass of soil in the solid phase (i.e., dried soil) to its total volume, including solid and pore volumes together. See Section C.8.1 for the density of building foundation material (concrete).

Units: grams per cubic centimeter (g/cm^3)

Probabilistic Input (applicable to soil medium):

Distribution: truncated normal

Defining Values for Distribution:

Mean value: 1.52　　Lower quantile value: 0.001

Standard deviation: 0.230　　Upper quantile value: 0.999

Discussion: Characteristics of the contaminated, unsaturated, and saturated zone are represented by several parameters, such as dry bulk density, total porosity, effective porosity, hydraulic conductivity, and others. These properties depend on the particle size distribution of the soil. Because the U.S. Department of Agriculture (USDA) soil texture classification is also based on the relative proportions of the different particle size classes, probability distributions for each of the parameters can be developed for each of the soil classes. These class-specific probability distributions of parameters for soil texture are more compact and relevant for each class of soil than an overall distribution encompassing all types of soils.

The dry bulk density, ρb, is related to soil particle density, ρs, by the total soil porosity, ρt, according to the following equation:

$$\rho_b = (1 - pt) \tag{C-1}$$

From the above definition, the value of the dry bulk density is always smaller than the value of the soil particle density. The soil particle density represents the density of the soil particles collectively and is expressed as the ratio of the solid phase mass to the volume of the solid phase of the soil. The soil particle density in soil minerals ranges from about 1.8 to 3.2 g/cm^3 (USDA 2009). However, in most mineral soils, the soil particle density has a narrow range of 2.6 to 2.7 g/cm^3 (Hillel 1980). This density is close to that of quartz, which is usually the predominant constituent of sandy soils. A typical value of 2.65 g/cm^3 has been suggested to characterize the soil particle density of a general mineral soil (Freeze and Cherry 1979; Beyeler et al. 1998b; USDA 2009). With that, the bulk density becomes:

$$\rho_b = (1 - pt) \times 2.65 \tag{C-2}$$

The density of cover material affects the degree of attenuation to the external radiation dose contributed by the cover material. The density of the contaminated zone determines the total mass of soil within a specified source volume. Because the radionuclide concentrations are specified in units of picocuries per gram (pCi/g), the density also determines the total amount of radionuclides within the volume. It is used to calculate the leach rate of radionuclides. Thus, the density has the potential of affecting all pathways. The dry bulk density of the unsaturated zone, along with other parameters, is used to calculate the breakthrough time for a radionuclide. (The “breakthrough time” is the time required for a material to reach the saturated zone.) The dry bulk density of the saturated zone, along with other parameters, is used to calculate the time required for contaminants to travel from the upgradient edge to the downgradient edge of the saturated zone.

Using data on bulk density, sand, and clay contents from a database compiled from soil survey information for 42 states, Carsel and Parrish (1988) inferred the saturated water content and reported the descriptive statistics for each of the 12 USDA soil classes. Meyer et al. (1997) reported that the saturated water contents are normally distributed. The distributions suggested here Table C-1 were computed by first assuming that the total porosity is equal to the saturated water content and then applying Equation (C-2).

The distribution to be used for cases in a generic setting was obtained as the weighted average of the distributions for the individual soil classes. In examining the Conterminous United States Multi-Layer Soil Characteristics (CONUS-SOIL) database, Beyeler et al. (1998b) found that approximately 85 percent of the area covered by materials with USDA classified soil textures is a consistent texture for the three uppermost layers (down to a depth of 20 cm). Volume weighted percentages of each of the 12 USDA soil textures were derived on the basis of areal distributions of the textures of the three uppermost CONUS-SOIL database layers. These percentages, as shown in Table C-2, were used to derive a soil density distribution for the generic soil type in RESRAD-ONSITE and RESRAD-OFFSITE codes. Note that the resulting distribution should be replaced by site-specific data when available. The likelihood of occurrence to be used is only valid to the depth (0.2 m) examined by Beyeler et al. (1998b). The actual contaminated soil depths considered under remedial actions can easily reach depths greater than 10 m. The CONUS-SOIL database itself only contains data for depths of 2.5 m or less. The probability density function of the weighted average was plotted, and the parameters of the normal distribution were chosen to represent the weighted average curve over the range of interest.

To be the most representative of sites across the United States, the default distribution in RESRAD-ONSITE and RESRAD-OFFSITE is that for the generic soil type. Its probability density function is shown in Figure C-1. When a site-specific analysis is being conducted, the distribution for the soil type present at the site should be used. For consistency, distributions corresponding to the same soil type selected for this parameter should also be selected for the following parameters: effective porosity, total porosity, hydraulic conductivity, and the soil b parameter. Moreover, proper correlations between bulk density, porosity, and effective porosity should also be used. For example, bulk density should be strongly negatively correlated with both total porosity and effective porosity, and total porosity and effective porosity should be strongly positively correlated.

Table C-1 Normal Distribution Values for Dry Bulk Density by Soil Type

Soil Type	Mean	Standard Deviation	Lower Limit	Upper Limit
Sand	1.5105	0.159	1.019	2.002
Loamy sand	1.5635	0.2385	0.827	2.3
Sandy loam	1.5635	0.2385	0.827	2.3
Sandy clay loam	1.6165	0.1855	1.043	2.19
Loam	1.5105	0.265	0.692	2.329
Silt loam	1.4575	0.212	0.802	2.113
Silt	1.431	0.2915	0.53	2.332
Clay loam	1.5635	0.2385	0.827	2.3
Silty clay loam	1.5105	0.1855	0.937	2.084
Sandy clay	1.643	0.1325	1.234	2.052
Silty clay	1.696	0.1855	1.123	2.269
Clay	1.643	0.2385	0.906	2.38
Generic soil type[a]	1.52	0.23	0.8136	2.234

[a] Parameters for the generic soil type are derived from the distribution enveloping all soil types. The lower and upper limits correspond to the 0.001 and 0.999 quantile values, respectively. Source: Derived from porosity values listed in Carsel and Parrish (1988).

Table C-2 CONUS-SOIL Texture Summary

USDA Soil Texture	Layer 1 [0-5 cm] (Percent of area)	Layer 2 [5-10 cm] (Percent of area)	Layer 3 [10-20 cm] (Percent of area)	Volume Weighed percent of 0-20 cm
Silt	0.005	0.005	0.015	0.01
Sandy clay	0	0.065	0.216	0.124
Sandy clay loam	0.398	0.65	1.323	0.923
Silty clay	1.569	1.623	1.316	1.456
Loamy sand	3.822	3.719	3.54	3.655
Clay	3.525	3.845	5.766	4.726
Clay loam	4.385	4.706	6.003	5.274
Silty clay loam	4.578	4.734	5.407	5.032
Sand	7.267	7.188	7.385	7.306
Sandy loam	23.541	22.673	21.792	22.45
Silt loam	25.339	25.336	24.424	24.881
Loam	25.571	25.456	22.813	24.163

Source: Beyeler et al. (1998b).

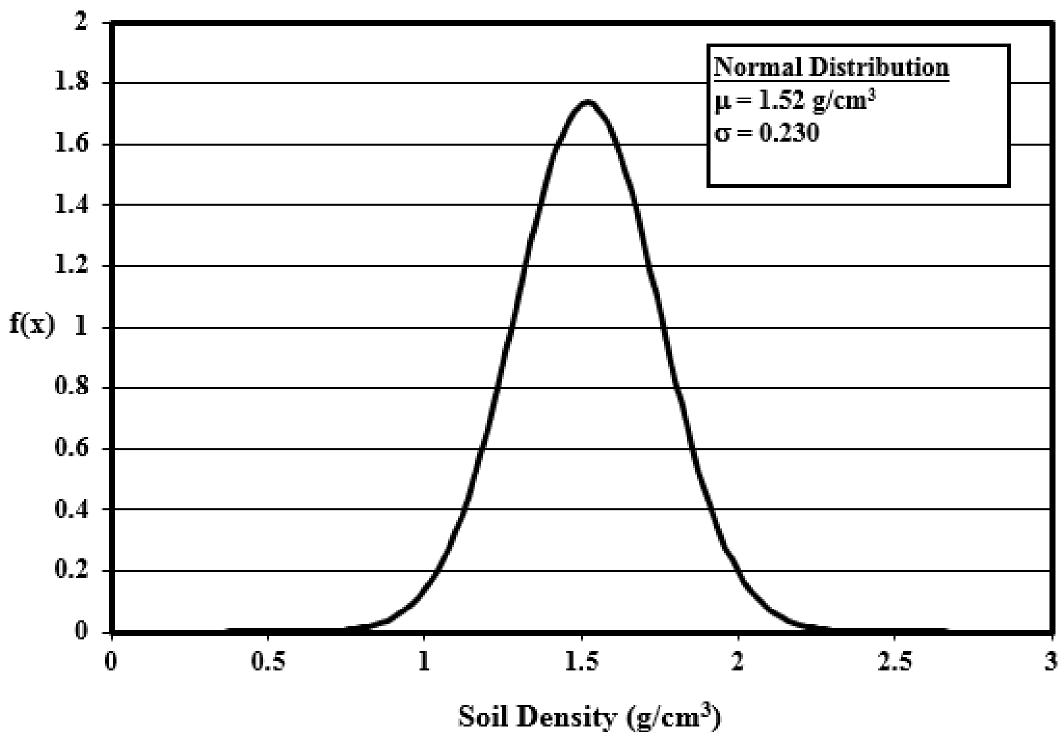

Figure C-1 Soil Density Probability Density Function for the Generic Soil Type

C.3.2 Total Porosity

Applicable Code: RESRAD-ONSITE and RESRAD-OFFSITE

Description: The total porosity of a porous medium is the ratio of the pore volume to the total volume for a representative sample of the medium. Separate input values are required for different media such as cover, contaminated, saturated, and unsaturated zones.

Units: no units

Probabilistic Input:

Distribution: truncated normal

Defining Values for Distribution:

Mean value: 0.425

Lower quantile value: 0.001

Standard deviation: 0.0867

Upper quantile value: 0.999

Discussion: Total porosity is one of the many parameters characterizing the contaminated, unsaturated, and saturated zones (see Section C.3.1). This parameter can be calculated in the following manner. Assuming that the soil system is composed of three phases—solid, liquid (water), and gas (air)—where V_s is the volume of the solid phase, V_l is the volume of the liquid phase, V_g is the volume of the gaseous phase, $V_p = V_l + V_g$ is the volume of the pores, and $V_t = V_s + V_l + V_g$ is the total volume of the sample, then the total porosity of the soil sample, p_t, is defined as:

$$p_t = \frac{V_p}{V_t} = \frac{V_l + V_g}{V_s + V_l + V_g} \tag{C-3}$$

The total porosity value is used along with the saturation ratio in determining the moisture content in soil, which in turn is used to determine the retardation factor and the transport speed of water in the contaminated zone. In the unsaturated zone, the total porosity value is used to calculate the breakthrough time. In the saturated zone, it is used to calculate the time required for radionuclides to move with groundwater from the upgradient edge to the downgradient edge of the contaminated zone.

Table C-1 lists the distribution of porosities (assumed to be equivalent to saturated water content) for different USDA soil classifications. The values in the table are taken from Carsel and Parish (1988) and are the same values suggested by Beyeler et al. (1998b). Carsel and Parish (1988) inferred the saturated water content from the data on bulk density and reported the descriptive statistics for the each of the 12 USDA soil classes. Meyer et al. (1997) report that the saturated water contents are normally distributed and that the distributions are applicable to total porosity.

Table C-3 Normal Distribution Values for Total Porosity by Soil Type

Soil Type	Mean	Standard Deviation	Lower Limit	Upper Limit	Number of Sampling Locations
Sand	0.43	0.06	0.2446	0.6154	246
Loamy sand	0.41	0.09	0.1319	0.6881	315
Sandy loam	0.41	0.0899	0.1322	0.6878	1183
Sandy clay loam	0.39	0.07	0.1737	0.6063	214
Loam	0.43	0.0998	0.1216	0.7398	735
Silt loam	0.45	0.08	0.2028	0.6972	1093
Silt	0.46	0.11	0.1161	0.7959	82
Clay loam	0.41	0.09	0.1319	0.6881	364
Silty clay loam	0.43	0.0699	0.214	0.646	641
Sandy clay	0.38	0.05	0.2255	0.5345	46
Silty clay	0.36	0.07	0.144	0.576	374
Clay	0.38	0.09	0.1019	0.6581	400
Generic soil type[a]	0.425	0.0867	0.157	0.693	5693

[a] Values for the generic soil type were derived from the distribution enveloping all soil types. The lower and upper limits correspond to the 0.001 and 0.999 quantile values, respectively. Source: Beyeler et al. (1998); Carsel and Parrish.(1988).

The Penn State University's Web site (http://www.essc.psu.edu/soil_info) maintains porosity data for each standard layer of each map unit for the conterminous United States. The map units have been gridded at a cell size of 1 km. The porosity data are available in several formats to accommodate users with a variety of geographical information system (GIS) software.

The distribution to be used when the type of soil is not known (the selected default for RESRAD-ONSITE and RESRAD-OFFSITE) was calculated as the weighted average of the distributions for the individual soil classes. The same weighting factor scheme as discussed for the generic soil type in Section C.3.1 was used. The probability density function of the weight average was plotted, and the parameters of the normal distribution were chosen to represent the weighted average curve over the range of interest. Figure C-2 displays the probability density function for total porosity for this generic soil type. When a site-specific analysis is conducted, the distribution for the soil type present at the site should be used. For consistency, distributions corresponding to the same soil type selected for this parameter should also be selected for the following parameters: soil density, effective porosity, hydraulic conductivity, and the soil b parameter.

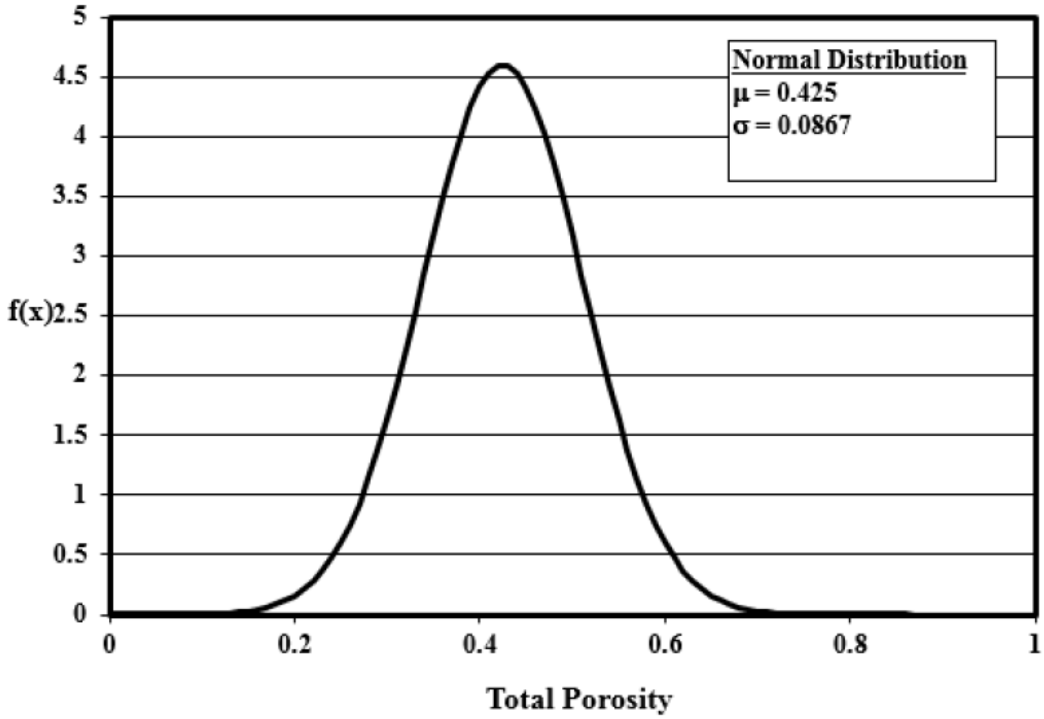

Figure C-2 Soil Density Probability Density Function for the Generic Soil Type

C.3.3 Effective Porosity

Applicable Code: RESRAD-ONSITE and RESRAD-OFFSITE

Description: The effective porosity (also called the kinematic porosity) of a porous medium is defined as the ratio of the part of the pore volume where the water can circulate to the total volume of the representative sample of the medium. Separate effective porosity input values for the unsaturated and saturated zones are required in RESRAD-ONSITE and RESRADOFFSITE.

Units: no units

Probabilistic Input:

Distribution: truncated normal

Defining Values for Distribution:

Mean value: 0.355 Lower quantile value: 0.001

Standard deviation: 0.0906 Upper quantile value: 0.999

Discussion: Effective porosity is one of the several soil parameters used to calculate the breakthrough time in the unsaturated zone. In the saturated zone, it is used to calculate the rise time (i.e., the time required to transport groundwater from the upgradient edge to the downgradient edge of the saturated zone). Several aspects of the soil system influence the value of its effective porosity: (1) the adhesion of water on minerals, (2) the absorption of water in the clay-mineral lattice, (3) the existence of unconnected pores, and (4) the existence of dead-end pores (Yu et al., 2015).

The effective porosity, p_e, also called the kinematic porosity, of a porous medium is defined as the ratio of the part of the pore volume where the water can flow to the total volume of a representative sample of the medium. In naturally porous systems such as subsurface soil, where the flow of water is caused by the composition of capillary, molecular, and gravitational forces, the effective porosity can be approximated by the specific yield, or drainage porosity, which is defined as the ratio of the volume of water drained by gravity from a saturated representative sample of the soil to the total volume of the sample.

The definition of effective (kinematic) porosity is linked to the concept of pore fluid displacement rather than to the percentage of the volume occupied by the pore spaces. The pore volume occupied by the pore fluid that can circulate through the porous medium is smaller than the total pore space; and, consequently, the effective porosity is always smaller than the total porosity. In a saturated soil system composed of two phases (solid and liquid) where (1) V_s is the volume of the solid phase, (2) $V_w = V_{iw} + V_{mw}$ is the volume of the liquid phase, (3) V_{iw} is the volume of immobile pores containing the water adsorbed onto the soil particle surfaces and the water in the dead-end pores, (4) V_{mw} is the volume of the mobile pores containing water that is free to move through the saturated system, and (5) $V_t = V_s + V_{iw} + V_{mw}$ is the total volume, the effective porosity can be defined as follows:

$$p_e = \frac{V_{mw}}{V_t} = \frac{V_{mw}}{V_s + V_{mw} + V_{iw}} \tag{C-4}$$

Another soil parameter related to the effective soil porosity is the field capacity, θ_r, also called specific retention, irreducible volumetric water content, or residual water content, which is defined as the ratio of the volume of water retained in the soil sample, after all downward gravity drainage has ceased, to the total volume of the sample. Considering the terms presented above for a saturated soil system, the total porosity p_t and the field capacity θ_r can be expressed, respectively, as follows:

$$p_t = \frac{V_{mw} + V_{iw}}{V_t} \tag{C-5}$$

and

$$\theta_r = \frac{V_{iw}}{V_t} \tag{C-6}$$

Therefore, the effective porosity is related to the total porosity and the field capacity according to the following expression:

$$P_e = P_t + \theta_r \tag{C-7}$$

Carsel and Parrish (1988) used data on bulk density to infer the saturated water content. They then applied the data on sand and clay contents and the inferred saturated water content to the multiple regression model developed by Rawls and Brakensiek (1985) to generate estimates of residual water content for the 12 USDA soil textural classifications. The estimates were fitted by either a normal distribution or a transformed normal distribution by using methods in Johnson (1987) and Johnson and Kotz (1970). Meyer et al. (1997) then used the data generated by Carsel and Parish (1988) for saturated water content and residual water content to develop distributions for effective porosity by subtraction. Table C-4 gives the distributions and the defining parameters for effective porosity for the 12 soil textural classes and for the generic soil type.

The distribution to be used for cases when the type of soil is not known (the default distribution) was obtained as the weighted average of the distributions for the individual soil classes. The same weighting factor scheme as discussed for the generic soil type in Section C.3.1 was used. The probability density function of the weight average was plotted, and the parameters of the normal distribution were chosen to represent the weighted average curve over the range of interest. The probability density function for the effective porosity for this generic soil type is shown in Figure C-3. When a site-specific analysis is being conducted, the distribution for the soil type present at the site should be used. For consistency, distributions corresponding to the same soil type selected for this parameter should also be selected for the following parameters: soil density, total porosity, hydraulic conductivity, and the soil b parameter. A strong positive correlation between effective porosity and total porosity should be used in the analysis to ensure that the value sampled for the effective porosity is less than the total porosity.

Table C-4 Distribution Type and Parameters for Effective Porosity by Soil Type

Soil Type	Distribution	Mean	Standard Deviation	Lower Limit	Upper Limit
Sand	Normal	0.383	0.0610	0.195	0.572
Loamy sand	Normal	0.353	0.0913	0.0711	0.635
Sandy loam	Normal	0.346	0.0915	0.0629	0.628
Sandy clay loam	Normal	0.289	0.0703	0.0723	0.507
Loam	Normal	0.352	0.101	0.0414	0.663
Silt loam	Normal	0.383	0.0813	0.132	0.634
Silt	Normal	0.425	0.110	0.0839	0.766
Clay loam	Normal	0.315	0.0905	0.0349	0.594
Silty clay loam	Normal	0.342	0.0705	0.124	0.560
Sandy clay	Normal	0.281	0.0513	0.122	0.439
Silty clay	Normal	0.289	0.0735	0.0623	0.517
Clay	Normal	0.311	0.0963	0.0138	0.609
Generic soil type[a]	Normal	0.355	0.0906	0.075	0.635

[a] Parameters for the generic soil type were derived from the distribution enveloping all soil types. The lower and upper limits correspond to the 0.001 and 0.999 quantile values, respectively. Sources: Carsel and Parrish (1988); Meyer et al. (1997).

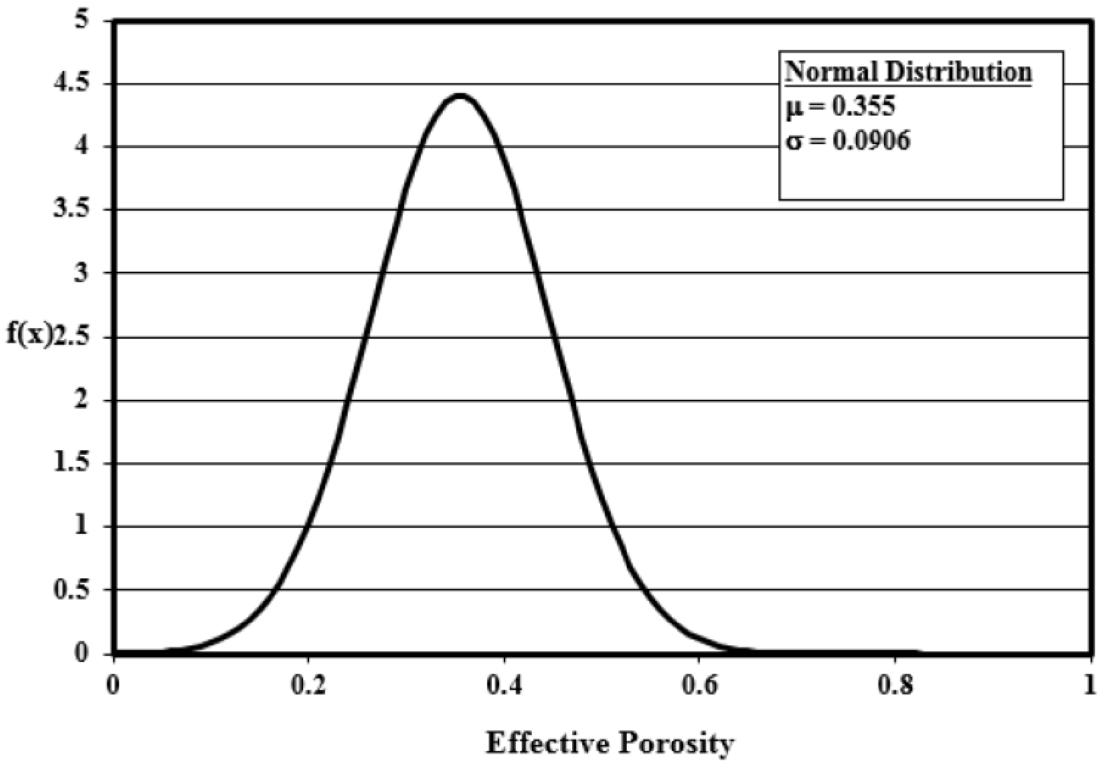

Figure C-3 Effective Porosity Probability Density Function for the Generic Soil Type

C.3.4 Hydraulic Conductivity

Applicable Code: RESRAD-ONSITE and RESRAD-OFFSITE

Description: The hydraulic conductivity of a soil is the measure of the ability of that soil to transmit water when subjected to a hydraulic gradient. RESRAD-ONSITE and RESRAD-OFFSITE use separate hydraulic conductivity values for three soil materials: contaminated, unsaturated, and saturated zones.

Units: meters per year (m/yr)

Probabilistic Input:

Distribution: bounded lognormal-n

Defining Values for Distribution:

Underlying mean value: 2.3	Lower limit: 0.004
Underlying standard deviation: 2.11	Upper limit: 9250

Discussion: The hydraulic conductivity (sometimes referred to as “coefficient of permeability”) is defined by Darcy’s law, which, for one-dimensional vertical flow, can be written as:

$$U = -k\frac{dh}{dz} \tag{C-8}$$

The U is Darcy's velocity (or the average velocity of the soil fluid through a geometric crosssectional area within the soil); h is the hydraulic head; z is the distance along the direction of groundwater flow in the soil, and K is the hydraulic conductivity.

The hydraulic conductivity of a soil governs the rate of groundwater flow within that soil. The rate of groundwater flow increases with increasing hydraulic conductivity. The hydraulic conductivity of a particular soil is affected by the size, abundance, and geometry of the open pores within the soil. Fine-grained soils, such as clay and silt, have very small pores and have much lower hydraulic conductivity than coarse-grained soils, such as sand and gravel.

The hydraulic conductivity in the contaminated zone is used along with the water infiltration rate and soil b parameter to determine the water saturation ratio in soil, which is then used to determine the leach rate of the contaminants (radionuclides). Leaching of radionuclides affects the doses for both the water-dependent and -independent pathways. In the unsaturated zone, the hydraulic conductivity is used in determining the moisture content of soil, which affects the retardation factor and the pore water velocity and, thus, the travel time in the unsaturated zone. In the saturated zone, hydraulic conductivity is used to determine the groundwater flow rate, which affects the travel time in the aquifer to the water point of use as well as the dilution factor for radionuclides in well water. The saturated hydraulic conductivity values related to the contaminated and unsaturated zones of the soil should represent the vertical component of hydraulic conductivity. For isotropic soil materials, the vertical and horizontal component of the hydraulic conductivity are the same; for anisotropic soils, the vertical component is typically one or two orders of magnitude lower than the horizontal component (Yu et al., 2015).

Distribution of saturated hydraulic conductivity is given in Carsel and Parrish (1988) for the 12 USDA soil textural classifications. Carsel and Parrish (1988) inferred the saturated water content from data on bulk density. They then applied data on sand and clay contents and the inferred saturated water contents to the multiple regression model developed by Rawls and Brakensiek (1985) to estimate saturated hydraulic conductivity for the 12 USDA soil textural classifications. The data were fitted by either a normal distribution or a transformed normal distribution using methods in Johnson (1987) and Johnson and Kotz (1970). Meyer et al. (1997) fitted the estimated data generated by Carsel and Parrish (1988) to the distribution forms that are more commonly used and more easily constructed. Meyer et al. (1997) used the following procedure:

- Generate realizations of the parameters using Latin Hypercube Sampling and the distributions from Carsel and Parrish (1988).
- Calculate the Kolmogorov D-statistic for a fit of each simulated parameter distribution to normal, lognormal, and beta distributions.
- Select the recommended distribution based on the D-statistic values.

In most cases, the distribution type with the smallest D-statistic value was selected as the recommended distribution. Table C-5 provides the distribution recommended by Meyer et al. (1997) on the basis of the soil type. The distribution to be used for cases when the type of soil is not known (the generic soil type) was obtained as the weighted average of the distributions for the individual soil classes. The same weighting factor scheme as discussed for the generic soil type in Section C.3.1 was used. The probability density function of the weighted average was plotted, and the parameters of the lognormal distribution were chosen to represent the weighted average curve over the range of interest. This generic soil type is the default distribution chosen for RESRAD-ONSITE and RESRAD-OFFSITE to be the most representative soil type found at sites across the United States. However, when evaluating a given site, the distribution most appropriate to local conditions should be used. The probability density function for hydraulic conductivity for this generic soil type is shown in Figure C-4 Hydraulic Conductivity Probability Density Function for the Generic Soil Type. When a site-specific analysis is being conducted, the distribution for the soil type present at the site should be used. For consistency, distributions corresponding to the same soil type selected for this parameter should also be selected for the following parameters: soil density, total porosity, effective porosity, and the soil b parameter.

Table C-5 Distribution Type and Parameter Values (m/yr) for Hydraulic Conductivity by Soil Type

Soil Type	Distribution[a]	Lower Limit[b]	Upper Limit[b]
Sand	Beta (1.398, 1.842, 110, 5870)	110	5,870
Loamy sand	Beta (0.7992, 1.910, 12.3, 4230)	12.3	4,230
Sandy loam	LN (5.022, 1.33)	2.49	9,250
Sandy clay loam	LN (3.36, 1.75)	0.129	6,440
Loam	LN (3.40, 1.66)	0.178	5,070
Silt loam	LN (2.26, 1.49)	0.096	960
Silt	LN (2.66, 0.475)	3.302	62.2
Clay loam	LN (1.36, 2.17)	0.00478	3,190
Silty clay loam	LN (0.362, 1.59)	0.0106	195
Sandy clay	LN (0.462, 2.02)	0.00309	816
Silty clay	LN (-1.238, 1.31)	0.00506	16.6
Clay	LN (0.302, 2.269)	0.00122	1,500
Generic soil type	Bounded Lognormal-N (2.3, 2.11, 0.004, 9250)	0.004[c]	9,250[c]

[a] LN (,) = lognormal distribution with two defining parameters,

Beta (,) = beta distribution and bounded lognormal-N with four defining parameters.

[b] Lower and upper limits are 0.001 and 0.999 quantiles for lognormal distribution.

[c] Corresponds to lower and upper observed values.

Sources: Beyeler (1998b); Meyer et al. (1997); Meyer and Gee (1999).

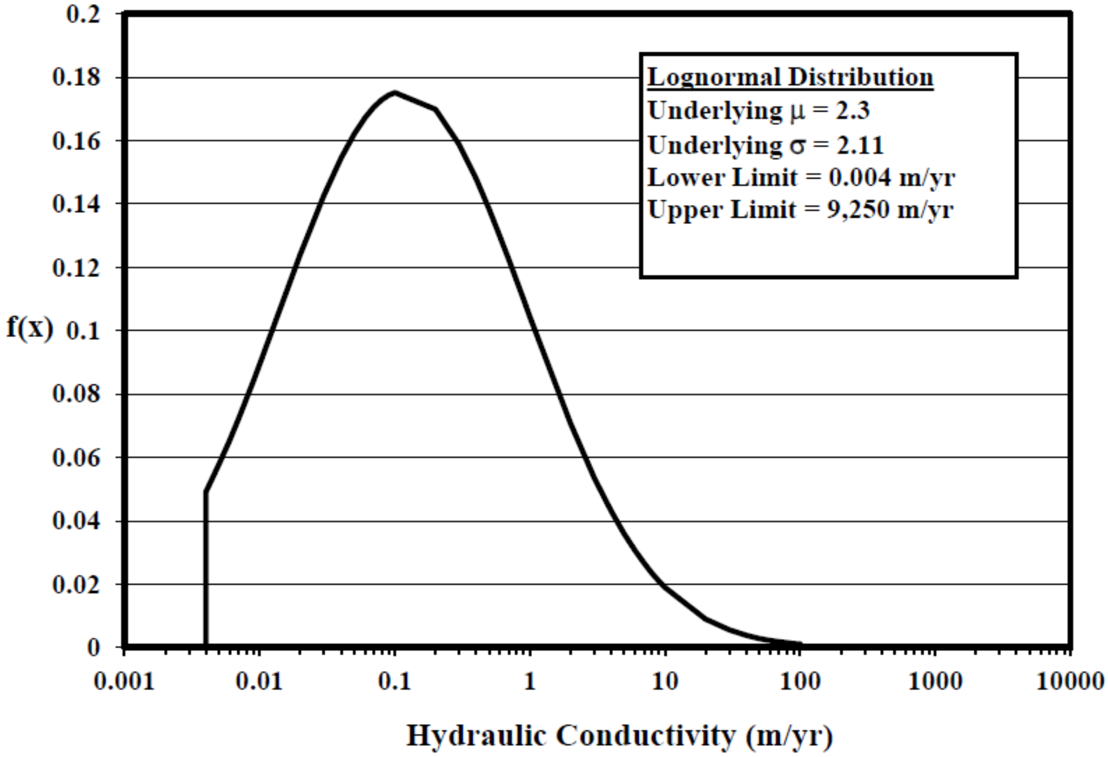

Figure C-4 Hydraulic Conductivity Probability Density Function for the Generic Soil Type

C.3.5 Soil b Parameter

Applicable Code: RESRAD-ONSITE and RESRAD-OFFSITE

Description: The soil-specific b parameter is an empirical parameter used to evaluate the saturation ratio of the soil. Three separate inputs are used in RESRAD-ONSITE, one each for the contaminated, unsaturated, and saturated zones. Two separate inputs are used in RESRAD-OFFSITE for the contaminated and unsaturated zones.

Units: no units

Probabilistic Input:

Distribution: bounded lognormal-n

Defining Values for Distribution:

Underlying mean value: 1.06	Lower limit: 0.5
Underlying standard deviation: 0.66	Upper limit: 30

Discussion: The following equation is used to evaluate the saturation ratio, Rs, in all unsaturated regions of the soil system (Yu et al., 2015):

$$R_s = \left(\frac{I_r}{K_{sat}}\right)^{\left(\frac{1}{2b+3}\right)} \quad \text{(C-9)}$$

I_r is the infiltration rate, and K_{sat} is the saturated hydraulic conductivity. When the medium is fully saturated, infiltration rate and hydraulic conductivity are equal, and saturation ratio equals unity.

The soil-specific exponential b parameter is one of several hydrological parameters used to calculate the radionuclide leaching rate in the contaminated zone and the moisture content in the unsaturated zone. In the code, the user is requested to input b parameter values for the contaminated zone, the unsaturated zone, and the saturated zone. (Input for the saturated zone b parameter will only be required if the water table drop rate is greater than 0.)

Meyer et al. (1997) derived a relationship for b by using the soil water retention parameters considered in Carsel and Parrish (1988). Using the derived relationship, Meyer et al. (1997) then constructed distributions for the soil-b parameter for the 12 USDA soil textural classifications. The distribution type and the parameters for the 12 soil types and for the generic soil type are provided in Table C-6. The distribution to be used for cases where the type of soil is not known (generic soil type) was obtained as the weighted average of the distributions for the individual soil classes. The distribution for the generic soil type is the RESRAD-ONSITE and RESRAD-OFFSITE default. The probability density function for the soil-b parameter for this generic soil type is shown in Figure C-5. When a site-specific analysis is being conducted, the distribution for the soil type present at the site should be used. For consistency, distributions corresponding to the same soil type selected for this parameter should also be selected for the following parameters: soil density, total porosity, effective porosity, and hydraulic conductivity.

Table C-6 Distribution Type and Parameter Values for Soil-b Parameter by Soil Type

Soil Type	Distribution[a]	Lower Limit[b]	Upper Limit[b]
Sand	LN (-0.0253,0.216)	0.501	1.9
Loamy sand	LN (0.305,0.258)	0.61	3.01
Sandy loam	LN (0.632,0.282)	0.786	4.5
Sandy clay loam	LN (1.41,0.275)	1.75	9.57
Loam	LN (1.08,0.271)	1.28	6.82
Silt loam	LN (1.28,0.334)	1.28	10.1
Silt	LN (1.16,0.140)	2.06	4.89
Clay loam	LN (1.73,0.323)	2.08	15.3
Silty clay loam	LN (1.96,0.265)	3.02	15.5
Sandy clay	LN (1.89,0.260)	2.97	14.8
Silty clay	LN (2.29,0.259)	4.43	22
Clay	Beta (1.751,11.61)	4.93	75
Generic soil type	Bounded lognormal-N (1.06,0.66,0.5,30)	0.5c	30c

[a] LN (,) = lognormal distribution with two defining parameters, Beta (,) = beta distribution and bounded lognormal-N with four defining parameters.
[b] Lower and upper limits are 0.001 and 0.999 quantiles for lognormal distribution.
[c] Correspond to lower and upper observed values. Sources: Beyeler et al. (1998b); Meyer et al. (1997); Meyer and Gee (1999).

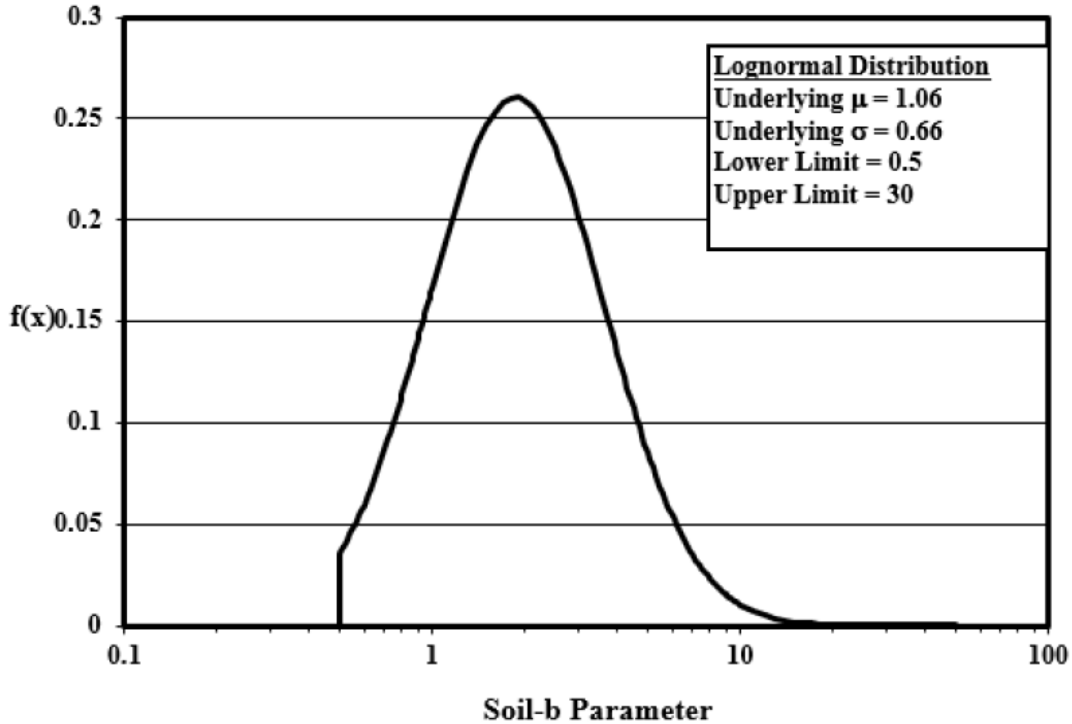

Figure C-5 Soil-b Parameter Probability Density Function for the Generic Soil Type

C.3.6 Hydraulic Gradient

Applicable Code: RESRAD-ONSITE and RESRAD-OFFSITE

Description: The hydraulic gradient is the change in hydraulic head per unit of distance of the groundwater flow in a given direction.

Units: no units

Probabilistic Input:

Distribution: bounded lognormal-n

Defining Values for Distribution:

Underlying mean value: -5.11	Lower limit: 7.0E-05
Underlying standard deviation: 1.77	Upper limit: 0.5

Discussion: The saturated zone hydraulic gradient is used to determine the groundwater flow rate, which affects the rise time as well as the dilution factor of radionuclides in well water. The hydraulic gradient, J_x, in the flow direction x, is expressed as follows:

$$J_x = \frac{h_1 - h_2}{\Delta x} \quad \text{(C-10)}$$

The h_1 and h_2 represent the hydraulic head at points 1 and 2, respectively, and x is the distance between these two points. In the code, the user is requested to input a value for the hydraulic gradient in the dominant groundwater flow direction in the underlying aquifer at the site.

In an unconfined (water table) aquifer, the horizontal hydraulic gradient of groundwater flow is approximately the slope of the water table. In a confined aquifer, it represents the difference in potentiometric surfaces over a unit distance. The potentiometric surface is the elevation to which water rises in a well that taps a confined aquifer. It is an imaginary surface analogous to a water table. In general, the hydraulic gradient of groundwater flow in a highly permeable geological material, such as sand or gravel, is far less than that in a geological material with a low permeability, such as silt and clay (Yu et al., 2015). Groundwater moves through an aquifer in a direction generally parallel to the hydraulic gradient. The movement generally is perpendicular to the lines of equal altitude of the potentiometric surface. The altitude of the potentiometric surface of different aquifer systems can be obtained from the Ground Water Atlas of the United States at http://wwwcapp.er.usgs.gov/publicdocs/gwa/.

The American Petroleum Institute, the National Water Well Association, and Rice University conducted a technical survey to collect hydrogeological information from groundwater professionals. Data gathered for 401 locations representing 48 United States' States (Newell et al., 1989) were analyzed for 12 hydrogeological environments on the basis of groupings of similar geologic settings. The data were collected for six hydrogeological parameters: hydraulic conductivity, seepage velocity, vertical penetration depth into saturated zone, hydraulic gradient, saturated thickness of aquifer, and depth to top of aquifer.

Newell et al. (1989) found that the hydraulic gradient was best described by a lognormal distribution. The raw data were used to calculate the mean, median, geometric mean, and standard deviations for each hydrogeological environment. Table C-7 provides values for these four statistics of the hydraulic gradient for 12 hydrogeological environments in the U.S. The default lognormal distribution listed above was obtained by conversion of the lognormal (base 10) distribution obtained for the national average in Newell et al. (1989). The probability density function for the hydraulic gradient is shown in Figure C-6.

Table C-7 Hydraulic Gradient (ft/ft) for 12 Hydrogeological Environments

Hydrogeological Environment	Number of Cases	Mean	Median	Standard Deviation	Geometric Mean
National Average	346	0.021	0.006	0.046	0.006
Metamorphic/Igneous	23	0.037	0.019	0.043	0.017
Bedded Sedimentary Rocks	52	0.023	0.009	0.027	0.011
Till Over Sedimentary Rocks	17	0.016	0.010	0.016	0.007
Sand and Gravel	223	0.027	0.005	0.068	0.005
River Valleys with Overbank	25	0.005	0.004	0.005	0.003
River Valleys Without Overbank	30	0.017	0.005	0.045	0.005
Alluvial Basins, Valleys and Fans	38	0.026	0.005	0.048	0.010
Outwash	26	0.005	0.002	0.077	0.003
Till and Till over Outwash	25	0.066	0.010	0.121	0.020
Unconsolidated and Semi consolidated	25	0.013	0.005	0.022	0.0033
Coastal Beaches	25	0.018	0.004	0.036	0.0037
Solution Limestone	17	0.016	0.006	0.029	0.0045

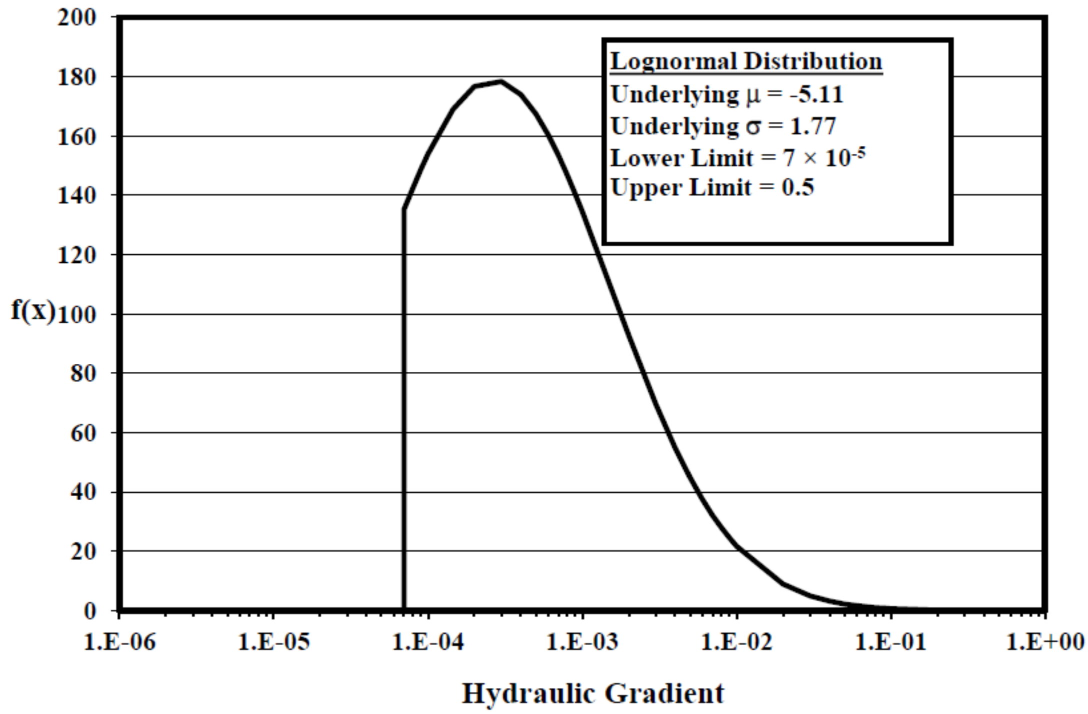

Figure C-6 Hydraulic Gradient Probability Density Function

C.3.7 Unsaturated Zone Thickness

Applicable Code: RESRAD-ONSITE and RESRAD-OFFSITE

Description: The uncontaminated unsaturated zone is the portion of the uncontaminated zone that lies below the bottom of the contaminated zone and above the water table. RESRAD-ONSITE and RESRAD-OFFSITE codes have provisions for up to five different horizontal strata (unsaturated zones). Each stratum is characterized by six radionuclide independent parameters: (1) thickness of the layer, (2) soil density, (3) total porosity, (4) effective porosity, (5) soil-specific b parameter, and (6) hydraulic conductivity.

Units: meters (m)

Probabilistic Input:

Distribution: bounded lognormal-n

Defining Values for Distribution:

Underlying mean value: 2.296	Lower limit: 0.18[1]
Underlying standard deviation: 1.276	Upper limit: 320

Discussion: Unsaturated zone thickness is the distance for the radionuclides must travel from the contaminated zone to reach the groundwater table. The greater the thickness, the longer it

[1] Corresponds to the cumulative probability of 0.1 percent.

takes for the travel time (breakthrough time). The breakthrough time affects the ingrowth and decay of radionuclides, factors that affect the amounts of radionuclides reaching the groundwater table.

In the code, the user is required to input a value for each stratum used in the calculation. Entering a nonzero thickness for a stratum activates that stratum; and, similarly, changing the thickness to zero deletes the stratum from calculations. By default, only one stratum is active in the code.

The American Petroleum Institute, the National Water Well Association, and Rice University collected hydrogeological information through a technical survey from groundwater professionals. Data from 401 locations representing 48 states in the United States were gathered (Newell et al., 1989). The data were analyzed for 12 hydrogeological environments on the basis of groupings of similar geologic settings. The data were collected for six hydrogeological parameters: hydraulic conductivity, seepage velocity, vertical penetration depth into saturated zone, hydraulic gradient, saturated thickness of aquifer, and depth to top of aquifer.

Newell et al. (1989) found that depth to the water table was best described by a lognormal distribution. The raw data were used to calculate the mean, median, geometric mean, and standard deviations for each hydrogeological environment. Newell et al. (1989) found that the coastal beaches, till, and the unconsolidated and semi-consolidated shallow aquifers had the least depth to water, with coastal beaches having a very low median value of 6 ft. (1.8 m). Alluvial basins had the highest median value at 25 ft. (7.6 m).

The probability distribution function for the unsaturated zone thickness was derived from data from Beyeler et al. (1998a), who used water table depths from U.S. Geological Survey (USGS) data sources on a 1.5-degree grid overlain onto a continental U.S. map. This grid was chosen to approximate the density of grid points per groundwater region to the areal density of the groundwater region. The average water level from the closest well to the grid point was used to assign a value of the water table depth for the grid. Values for all grid points were not found, but the data did include representative values from all regions. Table C-8 lists the empirical data. Bayesian estimation was used to fit the data in Table C-8 to a lognormal distribution. Figure C-7 and Figure C-8 show the probability density and cumulative density, respectively, for the unsaturated zone thickness.

Table C-8 Estimated Depth (m) to Water at Gridded Sampling Locations

Observation	Depth	Observation	Depth	Observation	Depth	Observation	Depth
1	0.30	54	3.88	107	8.99	160	27.22
2	0.67	55	4.17	108	9.00	161	27.30
3	0.81	56	4.25	109	9.13	162	27.57
4	0.92	57	4.44	110	9.14	163	27.73
5	0.99	58	4.44	111	9.20	164	27.78
6	1.03	59	4.63	112	9.31	165	27.99
7	1.07	60	4.87	113	9.55	166	28.60
8	1.14	61	5.13	114	9.59	167	29.44
9	1.21	62	5.18	115	9.63	168	30.06
10	1.30	63	5.54	116	9.86	169	30.34
11	1.31	64	5.83	117	10.47	170	30.34
12	1.32	65	5.85	118	10.71	171	30.55
13	1.56	66	5.86	119	11.31	172	30.75
14	1.58	67	5.90	120	11.54	173	31.12
15	1.61	68	6.06	121	11.67	174	31.69
16	1.69	69	6.13	122	11.97	175	31.70
17	1.69	70	6.17	123	12.57	176	31.74
18	1.69	71	6.22	124	12.63	177	32.23
19	1.78	72	6.31	125	12.79	178	33.87
20	1.80	73	6.36	126	13.15	179	34.82
21	1.81	74	6.40	127	13.24	180	35.44
22	1.84	75	6.46	128	13.35	181	36.04
23	1.87	76	6.51	129	13.37	182	36.77
24	1.92	77	6.55	130	13.62	183	40.30
25	2.04	78	6.60	131	13.68	184	40.72
26	2.10	79	6.86	132	13.75	185	42.37
27	2.11	80	6.92	133	14.09	186	42.88
28	2.32	81	6.92	134	14.49	187	44.18
29	2.36	82	6.95	135	15.05	188	47.17
30	2.37	83	6.97	136	15.23	189	49.66
31	2.39	84	7.09	137	16.08	190	51.15
32	2.44	85	7.18	138	16.22	191	61.31
33	2.44	86	7.35	139	16.49	192	61.90
34	2.45	87	7.36	140	16.56	193	62.28
35	2.59	88	7.40	141	16.85	194	63.15
36	2.63	89	7.43	142	17.38	195	65.87
37	2.69	90	7.46	143	18.17	196	67.33
38	2.79	91	7.59	144	18.42	197	74.67
39	2.81	92	7.60	145	18.43	198	79.24
40	2.90	93	7.64	146	18.66	199	81.17
41	2.95	94	7.87	147	19.45	200	82.81
42	3.07	95	8.10	148	20.05	201	84.72
43	3.18	96	8.28	149	20.68	202	89.58
44	3.22	97	8.35	150	20.76	203	94.68
45	3.29	98	8.70	151	21.69	204	107.60
46	3.34	99	8.71	152	22.37	205	113.13
47	3.37	100	8.73	153	22.73	206	114.78
48	3.44	101	8.79	154	22.86	207	141.71
49	3.58	102	8.80	155	22.94	208	176.91
50	3.61	103	8.82	156	24.01	209	177.99
51	3.66	104	8.85	157	24.66	210	180.25
52	3.74	105	8.89	158	25.96	211	315.85
53	3.86	106	8.90	159	26.47		

Source: Beyeler et al. (1998a).

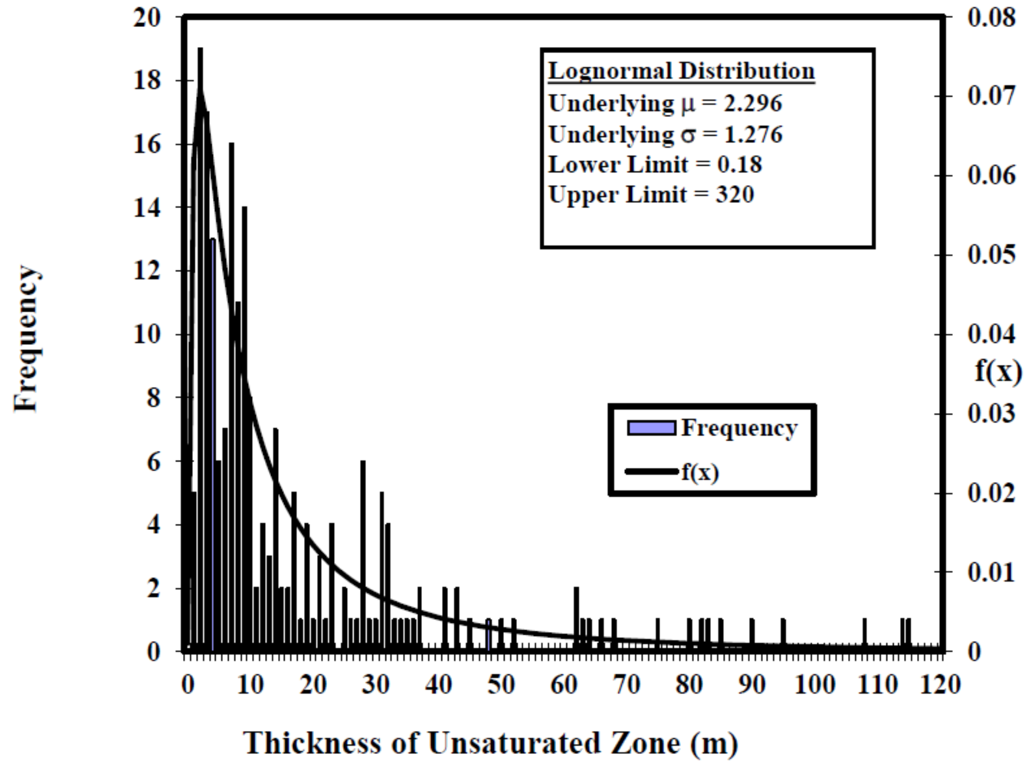

Figure C-7 Probability Density Function for Unsaturated Zone Thickness

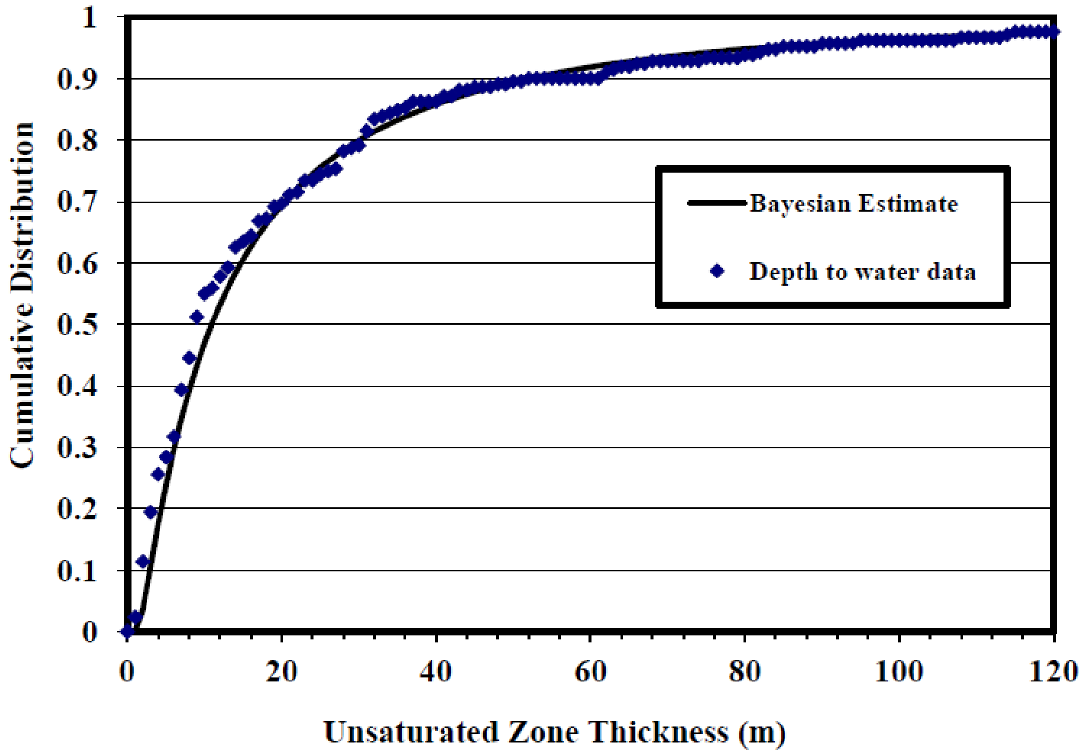

Figure C-8 Cumulative Distribution Function for Unsaturated Zone Thickness

C.3.8 Cover and Contaminated Zone Erosion Rate

Applicable Code: RESRAD-ONSITE

Description: The erosion rate is a measure of the amount of soil material that is removed from one place to another by running water, waves and currents, wind, or moving ice per unit of ground surface area and per unit of time. In RESRAD-ONSITE, the erosion rate is represented by the average depth of soil that is removed from the ground surface at the site per unit of time.

Units: meters per year (m/yr)

Probabilistic Input:

Distribution: user defined with continuous logarithmic interpolation n

Defining Values for Distribution: See Table C-9 for the cumulative distribution.

Discussion: The erosion rate is used in the RESRAD-ONSITE code to calculate the time dependence of the cover depth and the time dependence of the contaminated zone thickness. The contaminated zone erosion rate is only significant if and when the cover depth becomes zero.

Erosion rates for both the cover and the contaminated zone can be estimated by means of the Universal Soil Loss Equation (USLE), an empirical model that has been developed for predicting the rate of soil loss by sheet and rill erosion. If sufficient site-specific data are available, a site-specific erosion rate can be calculated. Details are discussed by Wischmeier and Smith (1978) and Foster (1979). Estimates based on the range of erosion rates for typical sites in humid areas east of the Mississippi River (based on model site calculations for locations in New York, New Jersey, Ohio, and Missouri) may also be used (Knight, 1983). For a site with a 2 percent slope, these model calculations predict an erosion rate range of 8.0E-07 to 3.0E-06 m/yr for natural succession vegetation, 1.0E-05 to 6.0E-05 m/yr for permanent pasture, and 9.0E-05 to 6.0E-04 m/yr for row-crop agriculture. The rate increases by a factor of ~3 for a 5 percent slope, 7 for a 10 percent slope, and 15 for a 15 percent slope. If these generic values are used for a farm-garden scenario in which the dose contribution from food ingestion pathways is expected to be significant, an erosion rate of 6.0E-04 m/yr should be assumed for a site with a 2 percent slope. This rate would result in erosion of 0.6 m of soil in 1,000 years. A proportionately higher erosion rate must be used if the slope exceeds 2 percent. An erosion rate of 6.0E-05 m/yr, leading to erosion of 0.06 m of soil in 1,000 years, may be used for a site with a 2 percent slope if it can be reasonably shown that the farm-garden scenario is unreasonable, for example, because the site is, and will likely continue to be, unsuitable for agriculture use.

Table C-9 Cover and Contaminated Zone Erosion Rate Cumulative Distribution

Erosion Rate (m/yr)	Cumulative Probability
5.0E-08	0
7.0E-04	0.22
5.0E-03	0.95
2.0E-01	1.0

The erosion rates are more difficult to estimate for arid sites in the west than for humid sites in the east. Although water erosion is generally more important than wind erosion, the latter can also be significant. Water erosion in the west is more difficult to estimate because it is likely to be due to infrequent heavy rainfalls for which the empirical constants used in the USLE may not be applicable. Long-term erosion rates are generally lower for sites in arid locations than for sites in humid locations. Pimentel (1976) has estimated that in the United States, soil erosion on agriculture land occurs at a rate of about 30 tons per hectare per year. (If the average soil density was assumed to be 1.5 g/cm^3 [mean for generic soil type] the average erosion rate would be 1.9E-03 m/yr.) Table C-10 gives the annual soil loss from various crops in different regions. Figure C-9 shows the fitted cumulative distribution function selected for input into RESRAD-ONSITE, along with the observed erosion.

Zuzel et al. (1993), in a study at a site in northeastern Oregon, reported on soil erosion for 12 years (1979-1989) from three treatments (continuous fallow, fall-seeded winter wheat, and fall-plowed wheat stubble). The authors observed that relatively rare events were the major contributors to the long-term soil losses. Table C-11 presents the soil erosion data for the three treatments. The site had a 16 percent north-facing slope, and the soil type was silt loam.

Baffault et al. (1998) analyzed frequency distributions of measured daily soil loss values and determined if the Water Erosion Prediction Project (WEPP) model accurately reproduced statistical distributions of the measured daily erosion rate. They fitted a log Pearson type III distribution to measured and WEPP-predicted soil loss values from six sites for periods ranging from 6 to 10 years. Cumulative soil loss results indicated that large storms contributed a major portion of the erosion under conditions where cover was high, but not necessarily under conditions of low cover. They found the maximum erosion rates of between 3 and 30 kg/m^2 for a given day for the six sites studied.

Table C-10 Annual Soil Loss from Land with Various Crops in Different Regions

Crop	Location	Slope (percent)	Soil Loss (tons/acre)	Estimated Annual Erosion Rate[a] (m/yr)
Corn (continuous)	Missouri (Columbia)	3.68	19.7	3.19 E-03
Corn (continuous)	Wisconsin (LaCrosse)	16	89	1.44E-02
Corn	Mississippi (northern)	NA[b]	21.8	3.54E-03
Corn	Iowa (Clarinda)	9	28.3	4.60E-03
Corn (plow-disk-harrow)	Indiana (Russell, Wea)	NA	20.9	3.39E-03
Corn (plow-disk-harrow)	Ohio (Canfield)	NA	12.2	1.98E-03
Corn (conventional)	Ohio (Coshocton)	NA	2.8	4.52E-04
Corn (conventional)	South Dakota (eastern)	5.8	2.7	4.36E-04
Corn (continuous chem.)	Missouri (Kingdom City)	3	21	3.41E-03
Corn (contour)	Iowa (southwestern)	2 to 13	21.4	3.48E-03
Corn (contour)	Iowa (western)	NA	24	3.90E-03
Corn (contour)	Missouri (northwestern)	NA	24	3.90E-03
Cotton	Georgia (Watkinsville)	2 to 10	19.1	3.10E-03
Cotton	Georgia (Watkinsville)	2 to 10	20.4	3.31E-03
Wheat	Missouri (Columbia)	3.68	10.1	1.64E-03
Wheat (black fallow)	Nebraska (Alliance)	4	6.3	1.02E-03
Wheat	Pacific Northwest (Pullman)	NA	5 to 10	8.10E-04 to 1.62E-03
Wheat-pea rotation	Pacific Northwest (Pullman)	NA	5.6	9.12E-04
Wheat (following fallow)	Washington (Pullman)	NA	6.9 to 9.9	1.12E-03 to 1.61E-03
Bermuda grass	Texas (Temple)	4	0.03	4.91E-06
Native grass	Kansas (Hays)	5	0.03	4.91E-06
Forest	North Carolina (Statesville)	10	0.002	3.27E-07
Forest	New Hampshire (central)	20	0.01	1.64E-06

[a] Estimated soil erosion assuming average soil density of 1.54 g/cm^3.
[b] NA = data not available. Source: Pimentel et al. (1976).

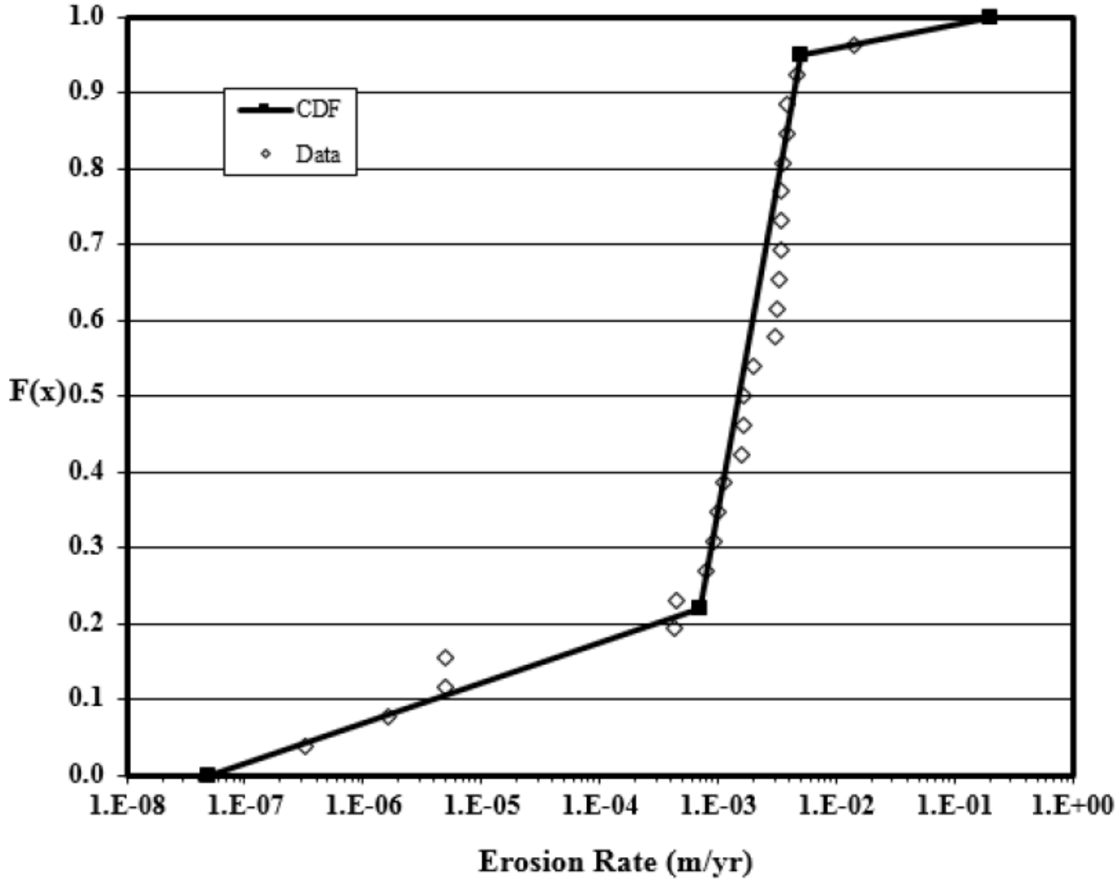

Figure C-9 Cumulative Distribution for Input to RESRAD-ONSITE for Erosion Rate

Table C-11 Soil Erosion at a Site in Northeastern Oregon for Three Treatments (1978-1989)

Treatment	Bulk Density (g/cm^3)	Erosion (t/ha)			Number of Events	Estimated Average Erosion Rate (m/yr)
		Total	Mean	Maximum		
Fall-seeded winter wheat	1.14	41.2	1.3	6.5	31	3.0E-04
Fall-plowed wheat stubble	-	22.6	1.4	9.6	16	2.0E-04[a]
Continuous fallow	1.23	461.9	5.4	53.3	86	3.1E-03

[a] For estimating average erosion, bulk density is assumed to be ~1 g/cm^3.

Source: Zuzel et al. (1993).

C.3.9 Distribution Coefficients

Applicable Code: RESRAD-ONSITE and RESRAD-OFFSITE

Description: The distribution coefficient, K_d, is the ratio of the mass of solute species adsorbed or precipitated on the solids per unit of dry mass of the soil, *S*, to the solute concentration in the liquids, *C*. The distribution coefficient represents the partition of the solute in the soil matrix and soil water, assuming that equilibrium conditions exist between the soil and solution phases (Yu et al., 2015).

Units: cubic centimeters per gram (cm^3/g) or liters per kilogram (L/kg)

Probabilistic Input:

Distribution: truncated lognormal-n

Defining Values for Distribution: Values are assigned according to the element of the radioactive isotope as given in Table C-12. Lower and upper quantile input values are 0.001 and 0.999 for all elements.

Discussion: The K_d values are used in RESRAD-ONSITE and RESRAD-OFFSITE code to estimate the relative transport of radionuclides to that of water in soil. The K_d values are dependent on the soil's physical and chemical characteristics, which do not necessarily remain constant over the long term because soils are dynamic systems. Soil properties affecting the K_d values include the texture of soils, the organic matter content of the soils, pH values, the soil solution ratio, the solution or pore water concentration, and the presence of competing cations and complexing agents (Yu et al. 2015).

Because of its dependence on many soil properties, the value of the distribution coefficient for a specific radionuclide in soils can range over several orders of magnitude under different conditions. To reduce the variability, the K_d values can be grouped on the basis of fundamental soil properties, such as soil texture and organic matter.

The probabilistic dose analysis capability was developed for the RESRAD-ONSITE code in 2000 (Yu et al. 2000), 53 elements K_d distributions were developed. In 2003, the International Atomic Energy Agency (IAEA) launched the program on Environmental Modeling for Radiation Safety (EMRAS), and one Working Group under this program worked on revising K_d values and transfer parameters for a large number of elements. Tables C.2.13.1 through C.2.13.5 in Yu et al. (2015) list the K_d data developed for different soil types (by the EMRAS Working Group (IAEA 2010a, Gil-Garcia et al. 2009a, Vandenhove et al. 2009, Gil-Garcia et al. 2009b). The data include geometric mean, geometric standard deviation, minimum and maximum values, and the mean and standard deviation of the underlying normal distribution. The data in these tables are from field and laboratory experiments with various contamination sources. The soils were grouped in five groups (sand, loam, clay, organic, and generic—all soil types combined) according to the sand and clay percentages and the organic matter content. The proposed distribution values in Table C-12 are for generic soil type and were obtained by reviewing the latest published compilation and analyses, NUREG/CR-5512 Volume 3, and using the K_d—CR correlation (Yu et al. 2000). If the soil type is known K_d distributions for known soil type from Data Collection Handbook (Yu et al. 2015) can be used.

Because K_d is one of the important input parameters that has a strong influence on the calculated results in the RESRAD-ONSITE and RESRAD-OFFSITE codes, a site-specific value, if available, should always be used for risk assessment. In its decommissioning guidance (Schmidt et al. 2006), the United States Nuclear Regulatory Commission (NRC) encourages licensees to use sensitivity analysis to identify the importance of K_d on the resulting dose either (1) to demonstrate that a specific value used in the analysis is conservative or (2) to identify whether site-specific data should be obtained (if the licensee believes K_d is overly conservative).

Table C-12 K_d Distributions Values for Different Elements

Element	Source[a]	Exp(μ)[b]	μ[c]	σ[d]
Ac	1	1,700	7.44	1.1
Ag	1	380	5.94	1.95
Al	3	633	6.45	3.22
Am	1	2,600	7.86	1.79
As	1	550	6.31	1.61
At	3	71	4.26	3.22
Au	2	158	5.07	3.22
Ba	2	45	3.80	8.13
Be	1	990	6.90	1.1
Bi	1	480	6.17	0.69
Bk	3	70	4.25	3.22
Br	1	56	4.03	1.1
C	2	21	3.04	1.82
Ca	1	8	2.08	1.1
Cd	1	150	5.01	2.2
Ce	1	1,200	7.09	1.61
Cf	2	158	5.07	3.22
Cl	1	0.3	-1.20	1.1
Cm	1	9,300	9.14	1.39
Co	1	480	6.17	2.77
Cr	1	40	3.69	3
Cs	1	1,200	7.09	1.95
Cu	1	530	6.27	1.1
Dy	3	935	6.84	3.22
Er	3	935	6.84	3.22
Es	3	1380	7.23	3.22
Eu	2	955	6.86	4.01

a The source of the distribution values is indicated by 1, 2, 3, or 4: (1) generic soil values from data collection handbook, (2) using the values from NUREG/CR-5512 Vol. 3, (3) using plant transfer factor and the correlation between K_d and plant transfer factor, (4) using the value from Yu et al. 2000.
b It is the median value.
c The mean of the underlying normal distribution after taking natural logarithm of the K_d values.
d The standard deviation of the underlying normal distribution after taking natural logarithm of the values. Standard deviation for data obtained from source 3 was set to 3.22 to consider a potential wide range of distribution.

Table C-12 K_d Distributions Values for Different Elements (cont.)

Element	Source[a]	Exp(μ)[b]	μ[c]	σ[d]
F	2	5	1.61	3.22
Fe	1	880	6.78	0.69
Fm	3	935	6.84	3.22
Ga	3	745	6.61	3.22
Gd	2	5	1.61	3.22
Ge	3	48	3.87	3.22
H	4	0.06	-2.81	0.5
Hf	1	2,500	7.82	1.1
Hg	2	158	5.07	3.22
Ho	1	930	6.84	1.1
I	1	7	1.95	1.61
In	2	158	5.07	3.22
Ir	2	158	5.07	3.22
K	1	13	2.56	1.39
La	2	5	1.61	3.22
Lu	3	935	6.84	3.22
Md	3	935	6.84	3.22
Mg	1	4	1.39	1.1
Mn	1	1,200	7.09	2.2
Mo	1	38	3.64	1.1
Na	1	3	1.10	1.1
Nb	1	1,500	7.31	1.39
Nd	2	158	5.07	3.22
Ni	1	280	5.63	1.95
Np	1	36	3.58	1.79
Os	2	158	5.07	3.22
P	1	87	4.47	1.61
Pa	1	2,000	7.60	1.1
Pb	1	2,100	7.65	2.3
Pd	1	180	5.19	0.69
Pm	2	5012	8.52	3.22
Po	1	180	5.19	1.61
Pr	2	158	5.07	3.22
Pt	3	24	3.18	3.22
Pu	1	740	6.61	1.39
Ra	1	2,500	7.82	2.56
Rb	1	210	5.35	1.1
Re	2	44	3.78	3.22
Rh	2	158	5.07	3.22

a The source of the distribution values is indicated by 1, 2, 3, or 4: (1) generic soil values from data collection handbook, (2) using the values from NUREG/CR-5512 Vol. 3, (3) using plant transfer factor and the correlation between K_d and plant transfer factor, (4) using the value from Yu et al. 2000.
b It is the median value.
c The mean of the underlying normal distribution after taking natural logarithm of the K_d values.
d The standard deviation of the underlying normal distribution after taking natural logarithm of the values. Standard deviation for data obtained from source 3 was set to 3.22 to consider a potential wide range of distribution.

Table C-12 K_d Distributions Values for Different Elements (cont.)

Element	Source[a]	Exp(μ)[b]	μ[c]	σ[d]
Ru	1	270	5.60	2.08
S	2	100	4.61	3.22
Sb	1	62	4.13	1.39
Sc	2	158	5.07	3.22
Se	1	200	5.30	1.1
Si	1	130	4.87	1.1
Sm	1	930	6.84	1.1
Sn	1	1,600	7.38	1.79
Sr	1	52	3.95	1.79
Ta	1	780	6.66	1.1
Tb	2	158	5.07	3.22
Tc	1	0.2	-1.61	2.2
Te	2	550	6.31	3.22
Th	1	1,900	7.55	2.3
Ti	3	1380	7.23	3.22
Tl	2	158	5.07	3.22
Tm	3	935	6.84	3.22
U	1	200	5.30	2.48
V	3	935	6.84	3.22
W	2	158	5.07	3.22
Y	1	47	3.85	1.39
Yb	3	935	6.84	3.22
Zn	1	950	6.86	2.4

a The source of the distribution values is indicated by 1, 2, 3, or 4: (1) generic soil values from data collection handbook, (2) using the values from NUREG/CR-5512 Vol. 3, (3) using plant transfer factor and the correlation between K_d and plant transfer factor, (4) using the value from Yu et al. 2000.
b It is the median value.
c The mean of the underlying normal distribution after taking natural logarithm of the K_d values.
d The standard deviation of the underlying normal distribution after taking natural logarithm of the values. Standard deviation for data obtained from source 3 was set to 3.22 to consider a potential wide range of distribution.

C.3.10 Well Pumping Rate

Applicable Code: RESRAD-ONSITE and RESRAD-OFFSITE

Description: This parameter represents the total volume of water withdrawn from the well for all purposes per unit time. It is used to estimate the dilution that occurs in the well. For a subsistence farmer (resident farmer) scenario, this volume would include that water extracted from the well to fill the water demand for the household, livestock, and crop irrigation.

Units: cubic meters per year (m^3/yr))

Probabilistic Input:

Distribution: none recommended

Defining Values for Distribution: Values are assigned according to the element of the radioactive isotope as given in Table C-12. Lower and upper quantile input values are 0.001 and 0.999 for all elements.

Discussion: The distribution being sought here is not that of the pumping rates of wells serving communities (large and small) but the water extraction rate of a well serving a single family farm. This family well would have to satisfy the dietary needs (drinking water, water used in cooking food, water used to clean foods) and the personal hygiene needs of the members of the farm household, the livestock water requirements (ingestion and cleaning), and any water needed for other agricultural activities (such as irrigating crops).

No general distribution is recommended for this parameter because of its large variability due to a number of site-specific considerations. A site-specific input distribution for well pumping rate can be determined as the sum of individual water needs. The water use components considered should include household water use including human drinking water intake, livestock intake, crop irrigation, and pasture irrigation. Summaries of household water use per occupant are given in EPA (1997); human drinking water intake is discussed in Section C.5.2; livestock intake will vary with the number and type of animals, and crop and pasture irrigation use will vary with the land area farmed. An even wider distribution will be obtained when uncertainties related to the fraction of contaminated water used are considered.

For perspective, Table C-13 presents three cases for which total water use is estimated. Each case assumes the same number of livestock and four occupants. Land area varies from 100 to 10,000 m^2, and the fraction of contaminated water used is varied for irrigation. All values used are taken from Yu et al. (2001), except the irrigation rate, which is from Yu et al. (2000).

Table C-13 Example Calculations for Estimating the Well Pumping Rate

Water Use Component	General Case	Water Use as a Function of Land Area		
		100 m^2	2,400 m^2	10,000 m^2
Household	225 × 4 L/d = 328.7 m^3 yr^{-1}	328.7 m^3 yr^{-1}	328.7 m^3 yr^{-1}	328.7 m^3 yr^{-1}
Livestock	50+160 L/d = 76.7 m^3 yr^{-1}	76.7 m^3 yr^{-1}	76.7 m^3 yr^{-1}	76.7 m^3 yr^{-1}
Irrigation of vegetable plot				
Contaminated fraction	fp = min(Area/2000, 0.5)	0	0.5	0.5
Irrigation rate	I (m yr^{-1})	0	0.1125 m yr^{-1}	0.1125 m yr^{-1}
Irrigation water	fp × Ir × 2000	0	112.5 m^3 yr^{-1}	112.5 m3 yr^{-1}
Irrigation of pasture				
Contaminated fraction	fm = Area/20,000 <: 1	0	0.065	0.445
Irrigation rate	Ir (m yr^{-1})	0	0.1125 m yr^{-1}	0.1125 m yr^{-1}
Irrigation water	fm × Ir × 20,000	0	146.3 m yr^{-1}	1001 m3yr^{-1}
Drinking water	409.5 × 4 L/yr = 1.64 m^3 yr^{-1}	1.64 m^3 yr^{-1}	1.64 m^3 yr^{-1}	1.64 m^3 yr^{-1}
Total (m^3 yr^{-1})		407	666	1519

C.3.11 Well Pump Intake Depth

Applicable Code: RESRAD-ONSITE and RESRAD-OFFSITE

Description: The well pump intake depth is the depth below the water table where the well pump intake is located.

Units: meters (m)

Probabilistic Input:

Distribution: triangular

Defining Values for Distribution:

Minimum: 6 Maximum: 30 Most likely: 10

Discussion: For most domestic well systems, the pump intake depth can be taken to be the difference between the top of the water table and the bottom of the well screen. If the depth to the bottom of the screen is not known, the completion depth of the well can serve as a surrogate. Most states maintain records of domestic and municipal well systems, but some of these databases do not contain information on the screen depth or water level in a given well. The water well information that is available can usually be obtained for free or a nominal fee by contacting the state agency responsible for natural resources.

At any given location, the well pump intake depth will vary according to temporal variations in the level of the water table. Pump intake depth must be sufficiently below the level of the water table to account for drawdown during pump operation and low water levels during periods of drought. Some states have minimum requirements. It is generally recommended that the well screen be positioned in the lower one-half or one-third of the aquifer (EPA, 1975). Positioning the well screen at the bottom of the aquifer allows for a larger screen length (therefore larger intake), more drawdown is available (permitting larger well yield), and, as mentioned above, well yield can better be maintained during periods of severe drought or over pumping (Driscoll, 1986). However, positioning the screen at or near the bottom of the aquifer may not be desirable or necessary in the case of extremely thick aquifers (it is not economical to drill the entire depth), where there is poorer water quality near the bottom (poor water quality can occur in any portion of the aquifer), or when it is most efficient to place the screen at the center of the aquifer (which is often the most uniform part of the aquifer; Driscoll, 1986).

In the absence of a nationwide database, a rough approximation of the well pump intake depth distribution can be made by using aquifer thickness data and the assumption that the wells are normally completed to the bottom of the aquifer. Data on thicknesses of 350 aquifers located across the continental United States were collected for a hydrogeological database (Newell et al., 1989). The reported median and geometric mean were 9.14 m (30.0 ft.) and 11.2 m (36.9 ft.), respectively, for the saturated thickness. The mean and standard deviation were reported as 27.3 m (89.6 ft.) and 68.3 m (224.0 ft.), respectively. For the input, a most likely value of 10 m was selected as the most likely value of a triangular distribution because it lies between the values of the median and the geometric mean. To hedge against variations in the level of the water table and pump drawdown, a minimum value of 6 m (20 ft.) was chosen. In addition, a screen length of 3 m (10 ft.) or longer is recommended for supporting domestic farming operations (Driscoll, 1986). Thus, any depth less than 6 m below the water table would result in a risk of dewatering the screen. Because of the costs involved, it is unlikely that a domestic well would be completed 30 m (100 ft.) below the water table; therefore, a maximum value of 30 m was selected for the distribution (Figure C-10).

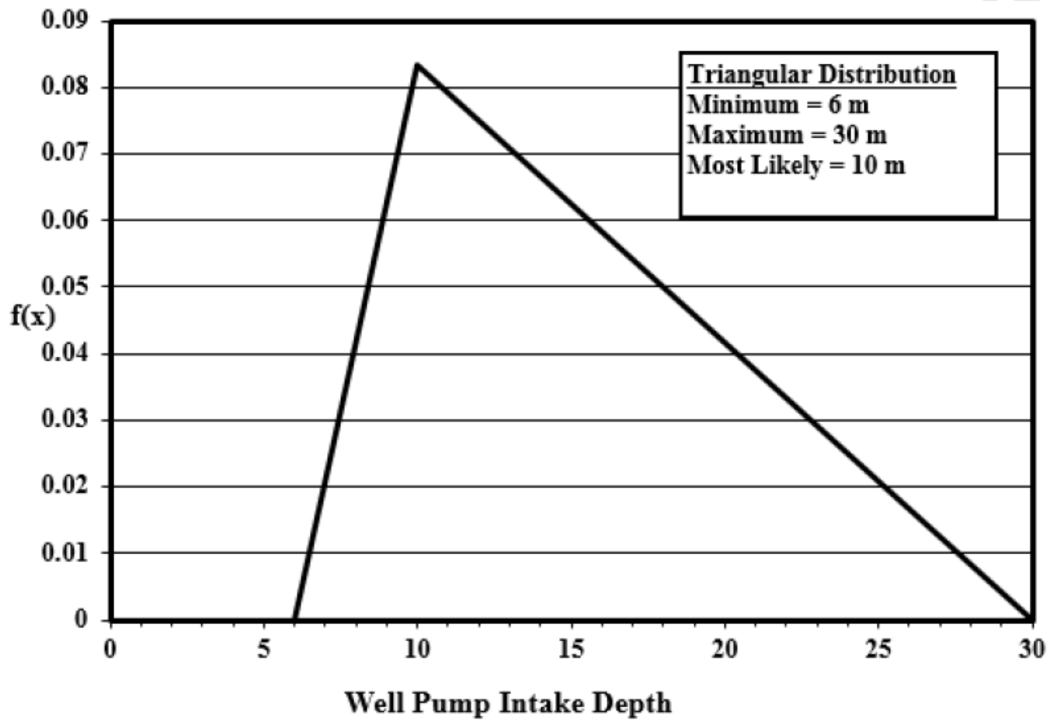

Figure C-10   Well Pump Intake Depth Probability Density Function

C.3.12 Depth of Soil Mixing Layer

Applicable Code: RESRAD-ONSITE and RESRAD-OFFSITE

Description: The depth of soil mixing layer parameter is used in calculating the depth factor for the dust inhalation and soil ingestion pathways and for foliar deposition for the ingestion pathway.

Units: meters (m)

Probabilistic Input:

Distribution: triangular

Defining Values for Distribution:

Minimum: 0.0 Maximum: 0.6 Most likely: 0.15

Discussion: The depth factor is the fraction of resuspendable soil particles at the ground surface that are contaminated. It is calculated by assuming that mixing of the soil with contamination will occur within the uppermost soil layer. The thickness of this layer is equal to the depth of the soil mixing layer.

Mixing of the upper soil layer can occur through atmospheric (wind or precipitation/runoff) and mechanical disturbances. For a residential farmer scenario, the greatest affected depths, on a routine basis, result from mechanical disturbances. Such disturbances include use of farm equipment (e.g., plowing) and foot and vehicle traffic. On relatively undisturbed portions of the land, a mixing layer depth close to 0 is expected. On the other hand, mixing of the soil to as deep as about 0.6 m (23 in.) is expected on the crop-producing portion of the land subject to periodic plowing and other agricultural activities.

A site-specific value should be used when available. A minimum depth close to 0.0 m on an agricultural field could apply. Over the past two decades, the practice of no-till farming has gained increasing popularity. The benefits of no-till farming include reduced soil particulate emissions and erosion, improved soil organic content, increased moisture content available to plants, and reduced CO2 emissions (USDA 2002).

Tillage of the soil for crop production should be as shallow as possible and still meet the objectives of aerating the soil, removing stubble, controlling weeds, incorporating fertilizer, controlling erosion, and providing a suitable seedbed and rootbed (Buckingham, 1984). Typical plow depths are on the order of 0.15 to 0.20 m (6 to 8 in.). However, a plow sole, or hardpan (compacted soil layer), can form when a field is plowed to the same depth each year (Buckingham, 1984). This compacted layer should be broken up periodically by plowing to a deeper depth so as not to restrict air and water movement. Deeper tillage of this type, down to approximately 0.6 m (23 in.), can be routinely achieved with commercially available equipment. Thus, the soil mixing layer depth is expected to range from 0 to 0.6 m for the residential farmer scenario. A triangular distribution for the soil mixing layer between these two values, with 0.15 m (6 in.) as a most likely value, was selected for use in RESRAD-ONSITE and RESRAD-OFFSITE codes as an approximation, because knowledge of the percentage of land used for crops and the crop types affect the amount of land and depth of plowing required, respectively. The probability density function for the soil mixing layer depth is shown in Figure C-11.

Tillage deeper than 0.6 m is possible, but it is considered to be a nonstandard practice (Dunker et al., 1995; Allen et al., 1995). Commercial equipment capable of tillage down to depths of 1.2 m are available (Dunker et al., 1995). One of the countermeasures attempted, with mixed results, to reduce contamination of foodstuffs following the Chernobyl accident was deep plowing (Konoplev et al., 1993; Vovk et al., 1993). Deep plowing had been considered to be a practical method for restoring large agricultural areas contaminated by radionuclides in the former USSR, with plow depths of approximately 0.6 to 0.75 m reported for different cases (Vovk et al., 1993).

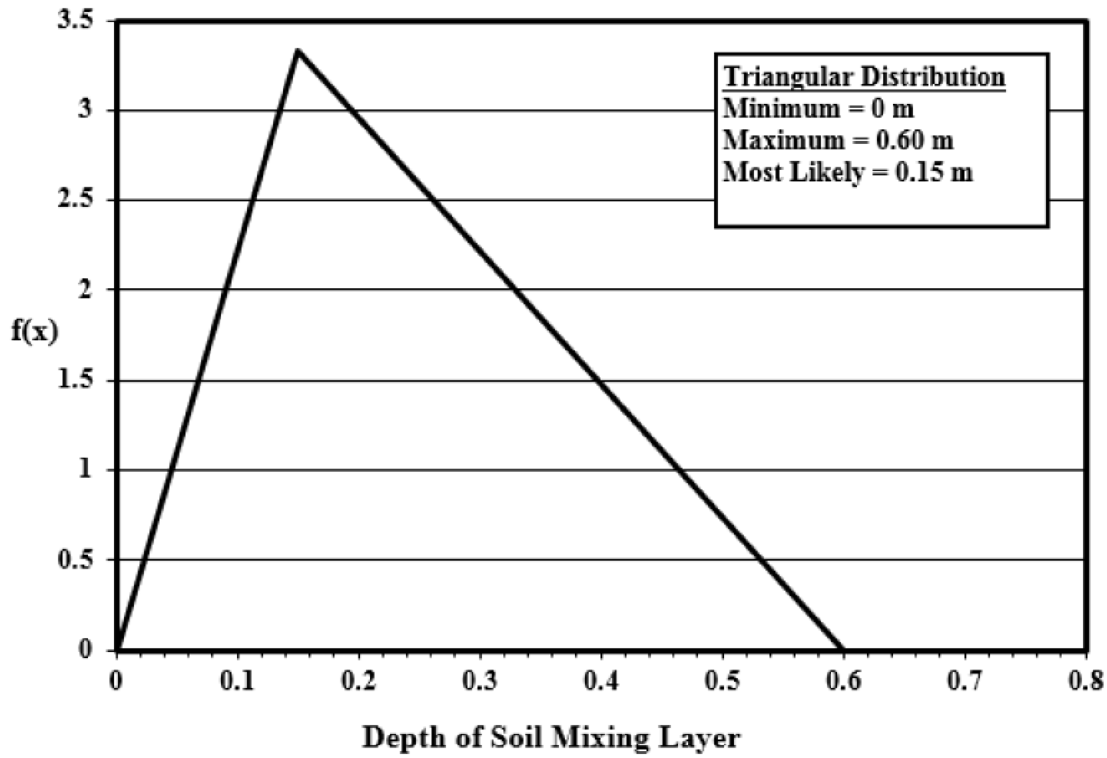

Figure C-11 Depth of Soil Mixing Layer Probability Density Function

C.3.13 Cover Depth

Applicable Code: RESRAD-ONSITE and RESRAD-OFFSITE

Description: The cover depth is the distance, in meters (m), from the ground surface to the location of the uppermost soil sample with radionuclide concentrations that are clearly above background.

Units: meters (m)

Probabilistic Input:

Distribution: none recommended

Discussion: The RESRAD-ONSITE and RESRAD-OFFSITE default for cover depth is 0, and that value is recommended for deriving soil guideline values. However, codes allow input of a cover depth greater than 0 when computing doses for a specific site where cover is present. The density of the cover material and the cover erosion rate are input only if a cover depth greater than 0 is used. Cover depth is very site specific; therefore, no distribution is provided.

C.3.14 Volumetric Water Content

Applicable Code: RESRAD-OFFSITE

Description: The volumetric water content is the fraction of the total volume of porous medium that is occupied by water.

Units: no units

Probabilistic Input:

Distribution: continuous linear n

Defining Values for Distribution: See Table C-14 for the input values.

Discussion: The volumetric water content of the cover material is used to calculate the radon flux from the primary contamination. In RESRAD-OFFSITE codes it is necessary to define an input value for the volumetric water content (θ) of the soil of the cover zone and the building foundation material (i.e., concrete). In RESRAD-ONSITE code it is necessary to define an input value for the volumetric water content (θ) of the building foundation material (i.e., concrete). For building foundation material (i.e., concrete), distribution developed for water fraction available for evaporation in Section C.8.9 should be used. In offsite receptor areas (dwelling location, and agricultural and livestock feed growing areas) in RESRAD-OFFSITE code it is used to calculate contaminant concentrations; and, for tritium, to calculate plant-to-soil transfer and the transfer to meat and milk.

The volumetric water content, as a measure of the soil water content (moisture content), will range between a minimum value represented by the residual water content (irreducible water content) and a maximum value given by the total porosity (Yu et al. 2015). The water content of a soil is influenced by a number of factors, including soil type (available pore space), local topology (drainage issues), and geographic location (weather issues). Thus, only a very generic distribution may be suggested in the absence of site-specific data. To be functional, the receptor areas modeled in RESRAD-OFFSITE are assumed to be in areas with relatively good drainage; that is, they are not part of water retention or detention areas and are not routinely flooded. As such, the volumetric water content is assumed to be equal to the field capacity for the development of a default parameter distribution. The field capacity is “generally interpreted as the water content at which drainage from a field soil becomes negligible” (Meyer et al. 1997). Equating the volumetric water content to the field capacity for use in RESRAD-OFFSITE is also reasonable because analysis periods are in the time frame of years. Over this period of time, the affected land is more often expected to be in some state where drainage has occurred. Variations will occur based on season, precipitation events/irrigation, and dry spells.

Table C-14 Cumulative Distribution Function for Volumetric Water Content

Volumetric Water Content	Cumulative Probability	Volumetric Water Content	Cumulative Probability
0.025	0.000	0.375	0.897
0.030	0.0002	0.40	0.934
0.040	0.003	0.425	0.961
0.047	0.010	0.45	0.979
0.056	0.028	0.48	0.991
0.070	0.070	0.53	0.999
0.080	0.104	0.56	1.000
0.10	0.175		
0.115	0.226		
0.13	0.272		
0.15	0.329		
0.29	0.705		
0.325	0.793		
0.35	0.849		

To address variations in soil type, Table C-15 lists the distribution of volumetric water content (assumed to be equivalent to the field capacity) for different United States Department of Agriculture (USDA) soil classifications. The values in the table are taken from Meyer et al. 1997) and based on the work of Carsel and Parish (1988). These distributions are either normal or lognormal depending on soil type.

The distribution to be used when the type of soil is not known (the selected default for RESRAD-OFFSITE) was calculated as the weighted average of the distributions for the individual soil classes. The weighting factor scheme was the same as that for the generic soil type discussed in Section C.3.1. The probability density function of the weighted average was plotted, and the parameters of a user-defined continuous function were chosen to represent the weighted average curve over the range of interest. Figure C-12 displays the cumulative distribution function for the volumetric water content for this generic soil type. When a site-specific analysis is conducted, the distribution for the soil type present at the site should be used. For consistency, distributions corresponding to the same soil type selected for this parameter should also be selected for the following parameters: soil density, total porosity, effective porosity, hydraulic conductivity, and the soil b parameter

Table C-15 Distribution Values for Volumetric Water Content by Soil Type

Soil Type	Distribution	Mean	Standard Deviation	Lower Limit	Upper Limit
Sand	LN (-2.83,0.241)[a]	0.0466	0.0106	0.0228	0.0907
Loamy sand	LN (-2.55,0.281)	0.0809	0.0224	0.0327	0.186
Sandy loam	LN (-2.21,0.314)	0.116	0.0369	0.0417	0.291
Sandy clay loam	LN (-1.59,0.254)	0.212	0.0568	0.0933	0.449
Loam	LN (-1.68,0.300)	0.194	0.0609	0.0735	0.468
Silt loam	Normal	0.252	0.0776	0.0119	0.491
Silt	Normal	0.236	0.0578	0.0575	0.415
Clay loam	LN (-1.27,0.297)	0.292	0.0862	0.112	0.700
Silty clay loam	Normal	0.347	0.0710	0.127	0.566
Sandy clay	LN (-1.23,0.210)	0.299	0.0623	0.153	0.559
Silty clay	Normal	0.334	0.0678	0.124	0.543
Clay	Normal	0.340	0.0893	0.0638	0.615

[a] LN (m,s) = lognormal distribution; m and s are the mean and standard deviation of the underlying normal distribution. Source: Meyer et al. (1997); Carsel and Parrish (1988).

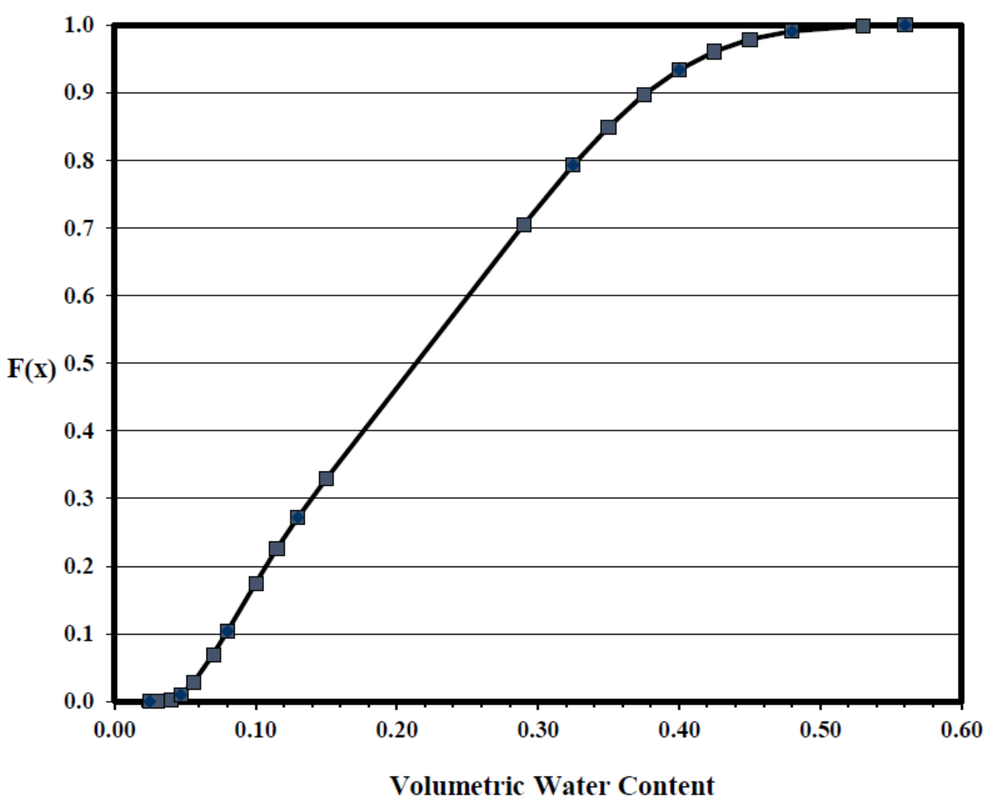

Figure C-12 Volumetric Water Content Cumulative Distribution Function

C.3.15 Dispersivity

Applicable Code: RESRAD-OFFSITE

Description: In a groundwater flow system modeled by the advection-dispersion equation, the dispersion of a contaminant in groundwater is characterized by the dispersion coefficient (or coefficient of hydrodynamic dispersion). The dispersion coefficient is composed of two components: mechanical mixing and diffusion. In coarse grain material such as sand, the dispersion caused by diffusion is relatively small and can be ignored. The dispersion caused by the mechanical mixing can be quantified by the dispersivity property (or dynamic dispersivity) of a porous medium.

Units: meters (m)

Probabilistic Input:

Distribution: continuous linear

Defining Values for Distribution: See Tables C-16 through C-18 for the input values.

Discussion: In the unsaturated zone, longitudinal dispersivity relates to the downward direction along the flow path. Preferential flow can occur through macropores in soil that are formed as aggregates of minerals, decayed root channels, cracks in clayey soils, and earthworm holes. These soil structures, though difficult to quantitatively define, can significantly affect various hydrogeological properties, including the dispersivity of soils (Vervoort et al. 1999).

Without direct site-specific measurements, a linear function may be used to derive the longitudinal dispersivity (EPA 2003):

$$\alpha_{LV} = 0.02 + 0.022 \times D_u \qquad \text{(C-11)}$$

D_u is the total depth of the unsaturated zone (m).

This equation was based on a regression analysis of laboratory and field data presented by the Electric Power Research Institute (EPRI 1985), with a vertical scale of experiments ranging from 0.23 to 20 meters and has a correlation coefficient of 0.66. A similar approach of using a linear function to estimate the longitudinal dispersivity was applied by the MEPAS codes. In MEPAS, the longitudinal dispersivity is assumed to be one percent of the thickness of the unsaturated zone (Ho et al. 2002).

A default nationwide landfill modeling analysis using the regional site-based methodology was performed for the EPA's Composite Model for Leachate Migration with Transformation Products (EPACMTP; EPA 2003). A distribution of values for longitudinal dispersivity was derived through Monte Carlo sampling of the unsaturated zone thickness from its Hydrogeologic Database for Groundwater Modeling. This distribution is summarized in Table C-16, shown in Figure C-13, and used in RESRAD-OFFSITE as the default distribution for longitudinal dispersivity for the unsaturated zone.

Table C-16 Cumulative Distribution for the Unsaturated Zone Longitudinal Dispersivity

Longitudinal Dispersivity (m)	Cumulative Probability
0.0267	0.00
0.057	0.10
0.107	0.25
0.154	0.50
0.354	0.75
0.423	0.80
0.665	0.85
0.959	0.90
1.00	0.95
1.00	1.00
Source: EPA (2003).	

The dispersivity in the saturated zone is measured in three directions. The longitudinal dispersivity is along the preferred groundwater flow direction (the x direction), and the horizontal transverse (y direction) and the vertical transverse (z direction) dispersivities are perpendicular to the flow direction.

Most studies of dispersion reported in the literature have involved relatively homogeneous sandy materials under controlled conditions in the laboratory. Based on 2,500 column dispersion tests on disturbed and undisturbed samples of unconsolidated geological materials, Klotz and Moser (1974) found that dispersivity increases with the grain size and the uniformity coefficient of grain-size distribution of samples. Less uniform materials (with higher uniformity coefficient) have higher dispersivities. Other soil physical parameters, such as grain shape, grain roughness, grain angularity, and compactness can also affect the dispersivity, but to a lesser extent. Taking all of these parameters into consideration, the dispersion coefficient is a characteristic quantity of a soil and is independent of permeability.

Though laboratory studies are important in understanding various factors affecting saturated zone dispersivity, field studies on dispersivity find more practical uses. Neuman (1990) demonstrated that longitudinal dispersivity increases with distance scale in a variety of hydrogeologic settings. In laboratory studies, Gelhar et al. (1992) found that values of longitudinal dispersivity are typically in the range of 0.1 to10 mm, with transverse dispersivity values normally lower by a factor of 5 to20. In the fields, the values of longitudinal dispersivity as large as 100 m and lateral dispersivity values as large as 50 m have been used in mathematical simulation studies of the migration of large contaminant plume in sandy aquifers (Gelhar et al. 1992). By using additional data and the data compiled by Gelhar et al. (1992), Schulze-Makuch (2005) suggested that the scaling relationship of longitudinal dispersivity can be described by the empirical power law:

$$\alpha_L = c\,(L)^m \qquad \text{(C-12)}$$

Where α_L is longitudinal dispersivity and L is flow distance and c and m are empirical fit constants with c and m varying with different geologic materials. In exploring the scaling effect of the longitudinal dispersivity, both Gelhar et al. (1992) and Schulze-Makuch (2005) emphasized the reliability of published data in their analyses. Eighty-eight high and immediate reliable category data compiled by Gelhar et al. (1992) and Schulze-Makuch (2005) for sediments were used to derive c and m (0.11 and 0.7 respectively). These values may be used in Equation C-13 to calculate the longitudinal dispersivity in saturated groundwater flow. The transverse dispersivities may then be estimated assuming that the longitudinal dispersivity is 8 times larger than the horizontal traverse dispersivity and 160 times larger than the vertical traverse dispersivity (EPA 2003).

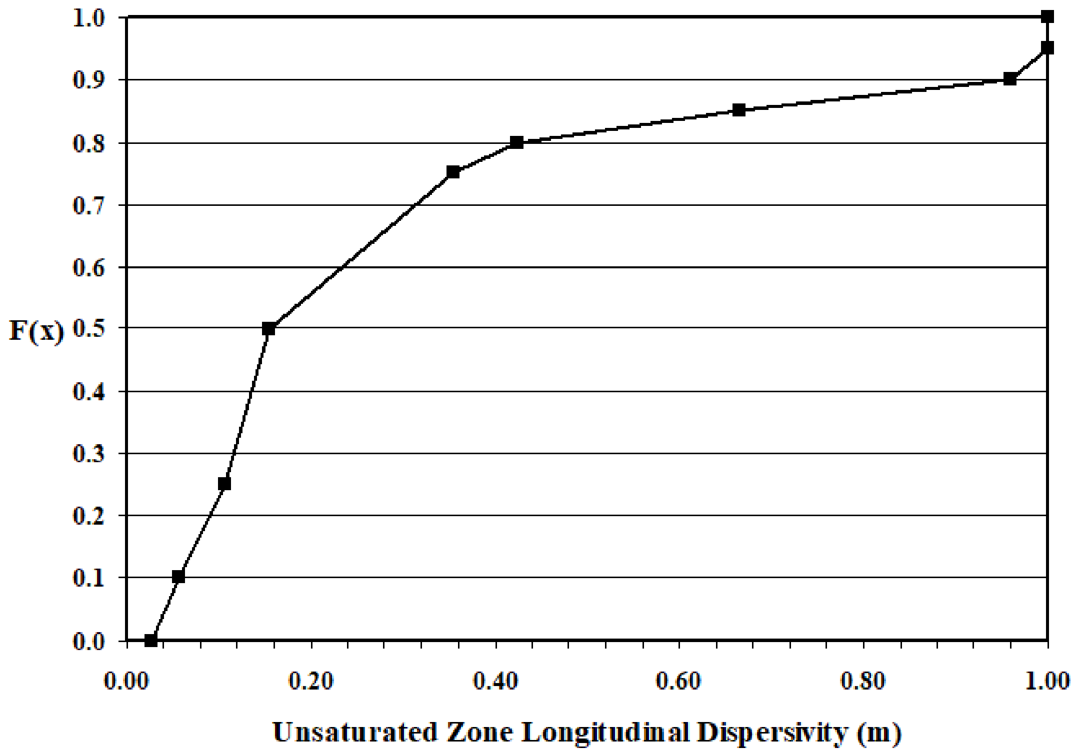

Figure C-13 Cumulative Distribution Function for the Unsaturated Zone Longitudinal Dispersivity

In the EPACMTP, a default modeling analysis, using the regional site-based modeling methodology, generated the CDF for longitudinal dispersivity for the saturated zone listed in Table C-17 and shown in Figure C-14. This distribution is the default for use in RESRAD-OFFSITE for general analyses. Site-specific analyses should employ site-specific data. The corresponding horizontal transverse and vertical transverse dispersivity distributions are provided in Table C-18 and Table C-19 and shown in Figure C-15 and Figure C-16, respectively.

Table C-17 Cumulative Distribution for the Saturated Zone Longitudinal Dispersivity

Longitudinal Dispersivity (m)	Cumulative Probability
0.100	0.00
1.22	0.10
3.62	0.25
8.96	0.50
25.4	0.75
43.2	0.80
65.3	0.85
92.1	0.90
135	0.95
318	1.00
Source: EPA (2003).	

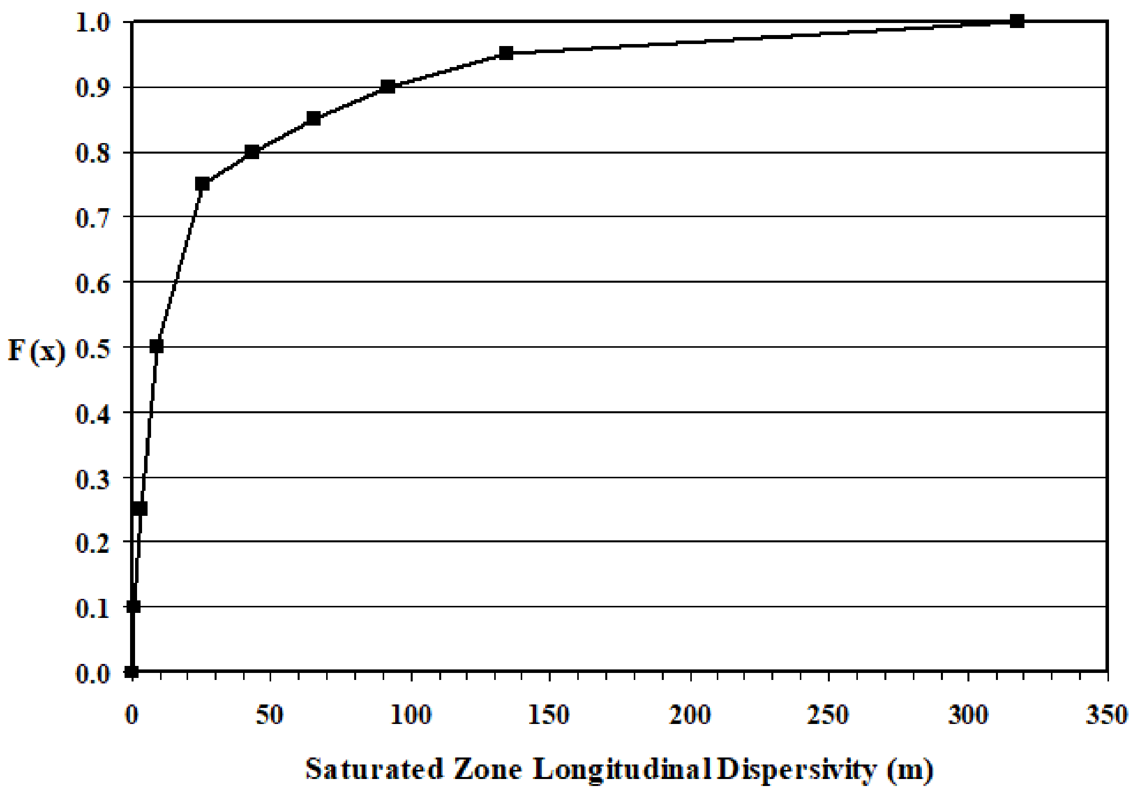

Figure C-14 Cumulative Distribution Function for the Saturated Zone Longitudinal Dispersivity

Table C-18 Cumulative Distribution for the Saturated Zone Horizontal Transverse Dispersivity

Longitudinal Dispersivity (m)	Cumulative Probability
0.0125	0.00
0.153	0.10
0.452	0.25
1.12	0.50
3.17	0.75
5.40	0.80
8.16	0.85
11.5	0.90
16.9	0.95
39.7	1.00
Source: EPA (2003).	

Table C-19 Cumulative Distribution for the Saturated Zone Vertical Transverse Dispersivity

Longitudinal Dispersivity (m)	Cumulative Probability
0.0100	0.00
0.0100	0.10
0.0226	0.25
0.0560	0.50
0.158	0.75
0.270	0.80
0.408	0.85
0.576	0.90
0.845	0.95
1.990	1.00
Source: EPA (2003).	

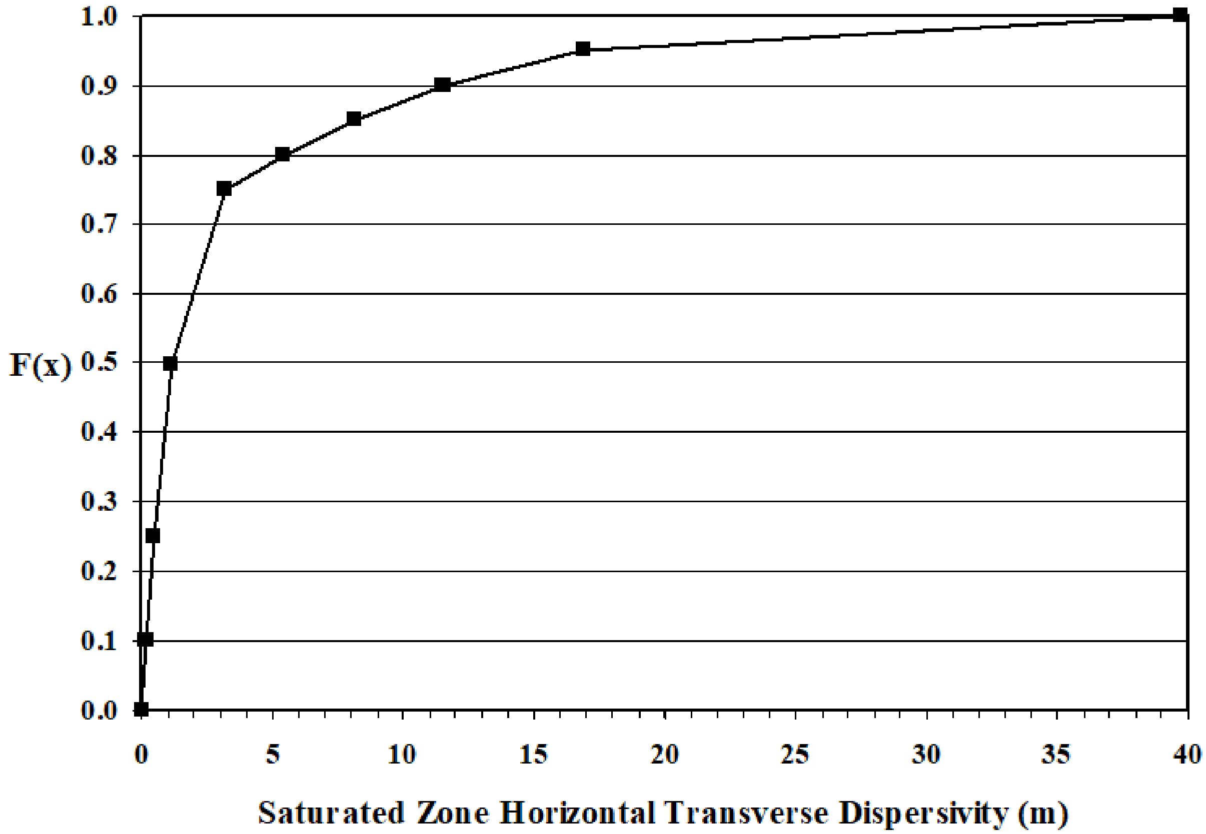

Figure C-15 Cumulative Distribution Function for the Saturated Zone Horizontal Transverse Dispersivity

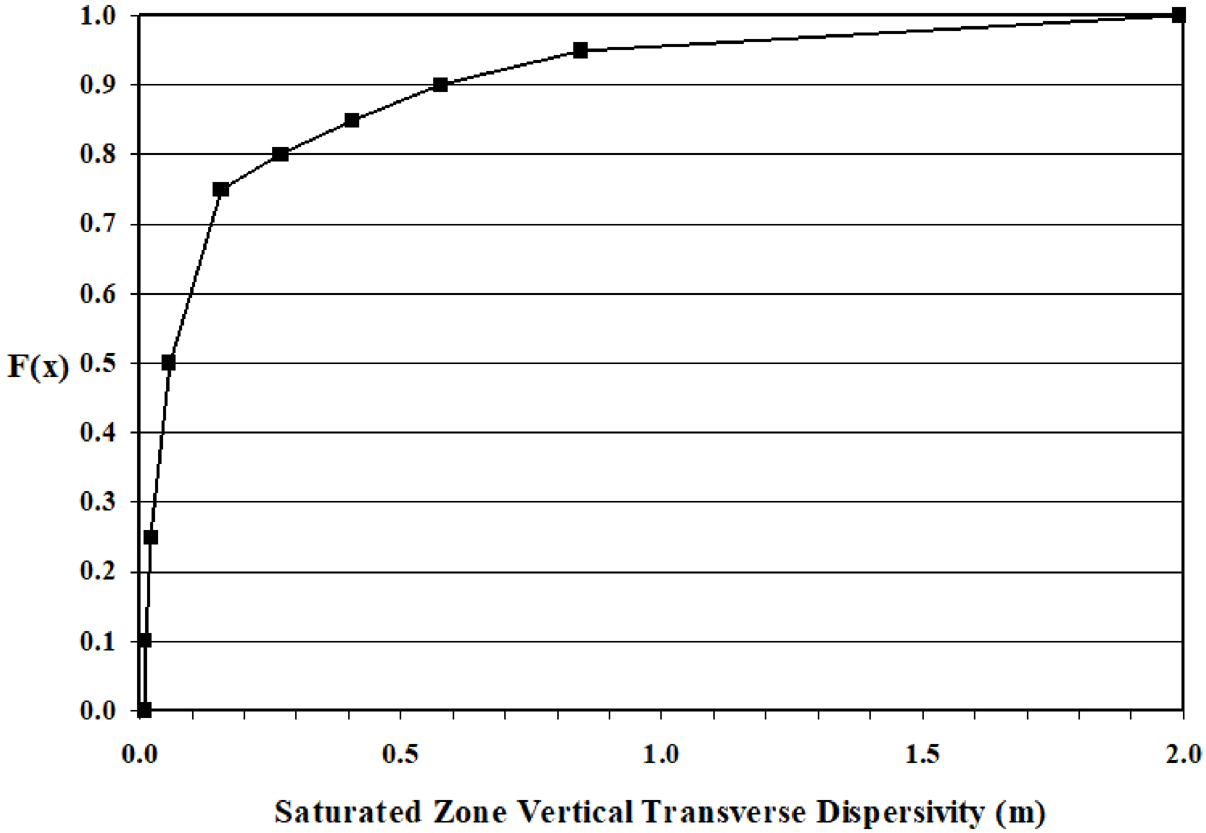

Figure C-16 Cumulative Distribution Function for the Saturated Zone Vertical Transverse Dispersivity

C.3.16 Rainfall Erosion Index

Applicable Code: RESRAD-OFFSITE

Description: The rainfall erosion index is a measure of soil erosion due to rainfall.

Units: no units

Probabilistic Input:

Distribution: continuous linear

Defining Values for Distribution: See Table C-20 for the input values.

Discussion: RESRAD-OFFSITE uses the soil erosion rate to estimate surface soil concentrations in the primary contamination area. These concentrations are used to estimate the release of radionuclide contaminants to the atmosphere and groundwater and are also used to calculate inhalation and soil ingestion doses to onsite receptors. The amount of contaminants released to the atmosphere is used to estimate the accumulation of the radionuclides downwind in the agricultural and livestock feed areas.

The universal soil loss equation (USLE; Wischmeier and Smith 1978) is used in RESRAD-OFFSITE to estimate the erosion rate of soil in contaminated and agricultural areas. The USLE was developed over many years as a tool in water and soil conservation planning to estimate long-term average soil losses as a function of different cropping and management systems. The equation is written as:

$$A = RKLSCP \tag{C-13}$$

A is the estimated soil loss per unit area, typically expressed in tons/acre/yr; *R* is the rainfall and runoff factor; *K* is the soil erodibility factor; *LS* is the slope length-steepness factor; *C* is the cover and management factor, and *P* is the support practice factor. The soil erodibility factor, the slope length-steepness factor, the cover and management factor, and the support practice factor are discussed further in Sections C.3.17 through C.3.20, respectively.

Table C-20 Cumulative Distribution for the Rainfall Erosion Index

Erodibility Factor (tons/acre)	Cumulative Probability
5	0.000777
65	0.177
123	0.341
200	0.683
315	0.863
400	0.967
475	0.991
600	1.00

The rainfall erosion index is used as the rainfall and runoff factor (*R*) in the USLE. The rainfall and runoff factor accounts for erosion due to rainfall and is defined as “the number of rainfall erosion index units, plus a factor for runoff from snowmelt or applied water where such runoff is significant” (Wischmeier and Smith 1978). The standard rainfall erosion index is a measure of the erosive forces due to rainfall and its runoff. An added term may be used to account for erosion due to surface thaws and snowmelt in northern sections of the United States. The suggested magnitude of the added term is 1.5 times the precipitation during December through March, measured as inches of water (Wischmeier and Smith 1978).

The rainfall erosion index can be evaluated on a storm by storm basis according to Wischmeier and Smith (1978) and Shen and Julien (1993):

$$R = 0.01 \sum EI \tag{C-14}$$

E is the kinetic energy of the storm (foot-tons per acre-inch), and *I* is the rainfall intensity (in/hr). The summation is performed over increments of the storm. The rainfall energy is directly related to the rainfall intensity:

$$E = 916 + 3311 \, log_{10} I \tag{C-15}$$

Soil erosion is highly dependent on site-specific parameters that are considered in the USLE. Local values for the rainfall erosion index can be estimated from Figure 1 in Wischmeier and Smith (1978), which provides isocontours of the index across the United States. This reference also provides 50-, 20-, and 5-percent probability values for the erosion index at 181 locations across the United States in addition to single storm values for EI. Local values will also vary on an annual basis. However, longer-term averages are more appropriate for use in RESRAD-OFFSITE when considering impacts for years, decades, or more in the future.

The Natural Resources Conservation Service (NRCS) of the USDA has published the 1997 National Resources Inventory (USDA 2001), which contains a database with records for over 800,000 locations within the United States. Each record contains values for the parameters in the USLE. Because the database is designed for the statistical analysis of general conditions and trends involving soil, water, and related resources, individual farms and fields are not identified. From these data, a default distribution for the rainfall erosion index has been developed for RESRAD-OFFSITE that provides a national coverage. The distribution is listed in Table C-20 and shown in Figure C-17. The appropriate value or distribution of values for a site-specific soil erosion index is best determined in consultation with the expert at your local state agricultural extension office.

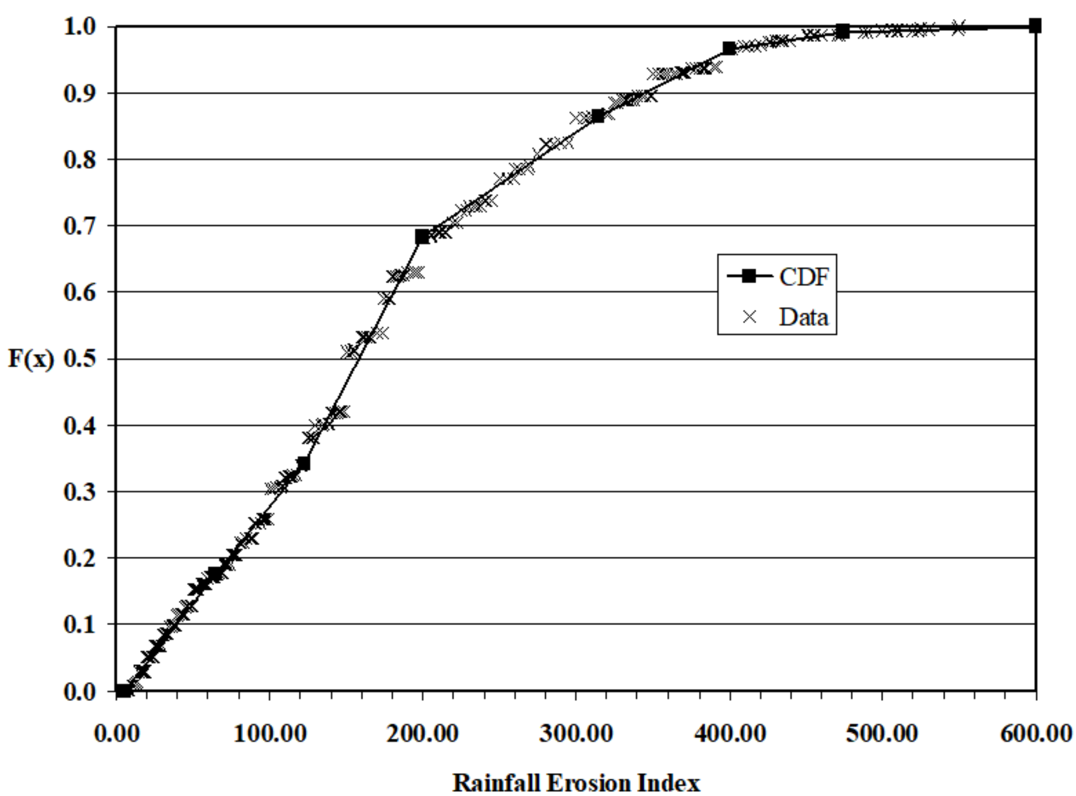

Figure C-17 Cumulative Distribution Function for the Rainfall Erosion Index

C.3.17 Soil Erodibility Factor

Applicable Code: RESRAD-OFFSITE

Description: The soil erodibility factor quantifies the susceptibility of soil to erosion processes.

Units: tons/acre

Probabilistic Input:

Distribution: continuous linear

Defining Values for Distribution: See Table C-21 for the input values.

Discussion: The soil erodibility factor (*K*) is part of the USLE, discussed previously in Section C.3.16. As incorporated into RESRAD-OFFSITE, the USLE estimates the amount of soil erosion that occurs in the primary contamination area. The soil erosion rate is used to estimate surface soil concentrations in the primary contamination area. These concentrations are used to estimate the release of radionuclide contaminants to the atmosphere and groundwater and are also used to calculate inhalation and soil ingestion doses to onsite receptors. The amount of contaminants released to the atmosphere is used to estimate the accumulation of the radionuclides downwind in the agricultural and livestock feed areas.

The inherent properties of the soil at a given location influence the soil erosion rate in addition to such factors as land slope, cover, management practices, precipitation events, and runoff. Relevant soil properties characterized by the soil erodibility factor include grain size distribution, texture, permeability, and organic content (Shen and Julien 1993). Sample values for the erodibility factor are listed in Table C-22 for two different levels of organic content. Further information on the soil erodibility factor, including a nomograph for determining its value, can be found in Wischmeier and Smith (1978). Additional discussion on the soil erodibility factor can be found in Renard et al. (1997).

Table C-21 Cumulative Distribution for the Erodibility Factor

Erodibility Factor (tons/acre)	Cumulative Probability
0.01	1.99E-06
0.08	0.00495
0.15	0.107
0.25	0.364
0.37	0.869
0.43	0.961
0.49	0.996
0.64	1.00

Table C-22 Soil Erodibility Factor (tons/acre)

Textural Class	Organic Matter Content, (percent)	
	0.5	**2**
Fine sand	0.16	0.14
Very fine sand	0.42	0.36
Loamy sand	0.12	0.1
Loamy very fine sand	0.44	0.38
Sandy loam	0.27	0.24
Very fine sandy loam	0.47	0.41
Silt loam	0.48	0.42
Clay loam	0.28	0.25
Silty clay loam	0.37	0.32
Silty clay	0.25	0.23
Source: Shen and Julien (1993).		

The NRCS of the USDA has published the 1997 National Resources Inventory (USDA 2001), which contains a database with records for over 800,000 locations within the United States. Each record contains values for the parameters in the USLE. Because the database is designed for the statistical analysis of general conditions and trends involving soil, water, and related resources, individual farms and fields are not identified. From these data, a default distribution for the soil erodibility factor has been developed for RESRAD-OFFSITE that provides a national coverage. The distribution is listed in Table C-21 and shown in Figure C-18. The appropriate value or distribution of values for a site-specific soil erodibility factor is best determined in consultation with the expert at your local state agricultural extension office.

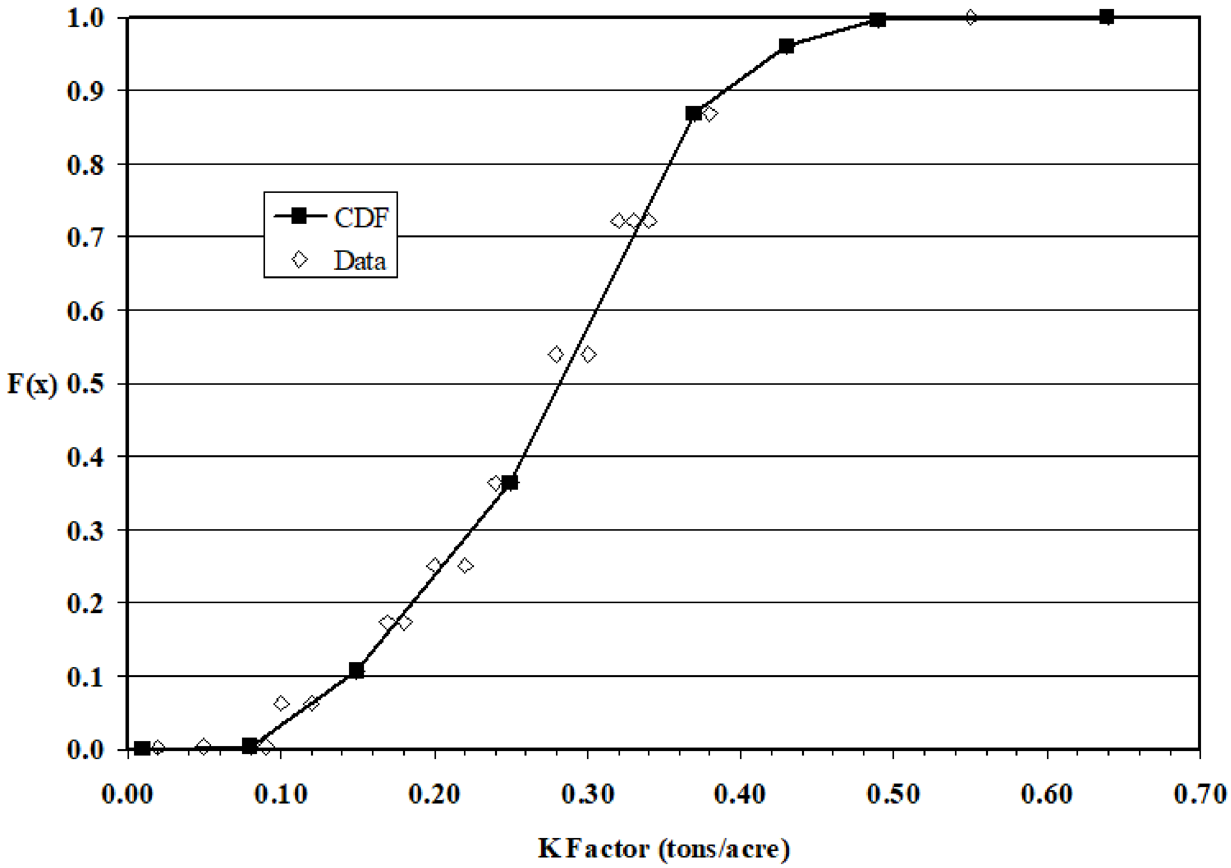

Figure C-18 Soil Erodibility Factor Cumulative Distribution Function

C.3.18 Slope Length-Steepness Factor

Applicable Code: RESRAD-OFFSITE

Description: The slope length-steepness factor accounts for the effect of length and steepness of the land slope on erosion processes.

Units: no units

Probabilistic Input:

Distribution: continuous linear

Defining Values for Distribution: See Table C-23 for the input values.

Discussion: The slope length-steepness factor (*LS*) is part of the USLE, discussed previously in Section C.3.16. As incorporated into RESRAD-OFFSITE, the USLE estimates the amount of soil erosion that occurs in the primary contamination area. The soil erosion rate is used to estimate surface soil concentrations in the primary contamination area. These concentrations are used to estimate the release of radionuclide contaminants to the atmosphere and groundwater and are also used to calculate inhalation and soil ingestion doses to onsite receptors. The amount of contaminants released to the atmosphere is used to estimate the accumulation of the radionuclides downwind in the agricultural and livestock feed areas.

The slope length-steepness factor is the ratio of soil loss per unit area from a field slope to that from a 72.6 ft. length of uniform 9 percent slope under otherwise identical conditions (Wischmeier and Smith 1978). As the name implies, this factor is actually a combination of the slope length factor (*L*) and the slope steepness factor (*S*) which are often considered together as the single topographic factor, *LS.* The slope length factor is the ratio of field soil loss to the corresponding 72.6 ft. slope length, given as (Wischmeier and Smith 1978):

$$L = \left(\frac{\lambda}{72.6}\right)^{m} \tag{C-16}$$

Where *λ* is the field slop length (ft.), and *m* is 0.2 when the slope percent slope is < 1 percent, 0.3 for slops of 1 to 3 percent, 0.4 for slops of 3.5 to 4.5 percent, or 0.5 for slopes ≥ 5 percent. The slope percent is defined as vertical distance divided by the horizontal distance multiplied by 100 (i.e., rise/run x 100 for a given slope).

Table C-23 Cumulative Distribution for the Slope Length-Steepness Factor

Slope Length – Steepness Factor	Cumulative Probability
0.0316	0.000206
0.15	0.301
0.30	0.566
0.60	0.745
1.5	0.893
5.00	0.978
20.0	0.998
49.25	1.00

The slope steepness factor (*S*) is evaluated by Wischmeier and Smith (1978):

$$S = 65.41\, sin^2\theta + 4.56\, sin\,\theta + 0.065 \tag{C-17}$$

$$\theta = angle\ of\ slope = tan^{-1}\left(\frac{slope\ percent}{100}\right) \tag{C-18}$$

The slope length-steepness factor (*LS*) is then given by the combination of Equations (C-17) and (C-18):

$$LS = \left(\frac{\lambda}{72.6}\right)^{m}\left(65.41\, sin^2\theta + 4.56\, sin\,\theta + 0.065\right) \tag{C-19}$$

Additional information about determining the proper values for *L* and *S* can be found in Wischmeier and Smith (1978) and Renard et al. (1997), including adjustments for irregular slopes or varying soil types. In addition, the values for m listed above for use in Equation (C-17) are only average values. Renard et al. (1997) provide more detailed data on refining the value of *m* for a specific field slope.

The NRCS of the USDA has published the 1997 National Resources Inventory (USDA 2001), which contains a database with records for over 800,000 locations within the United States. Each record contains values for the parameters in the USLE. Because the database is designed for the statistical analysis of general conditions and trends involving soil, water, and related resources, individual farms and fields are not identified. From the values of slope length and slope percent from these data, a default distribution for the slope length-steepness factor has been developed for RESRAD-OFFSITE, by using Equation (C-19), which provides a national coverage. The distribution is listed in Table C-23 and shown in Figure C-19. The appropriate value or distribution of values for a site-specific slope length-steepness factor are best determined by using Equation (C-19) or in consultation with the expert at your local state agricultural extension office.

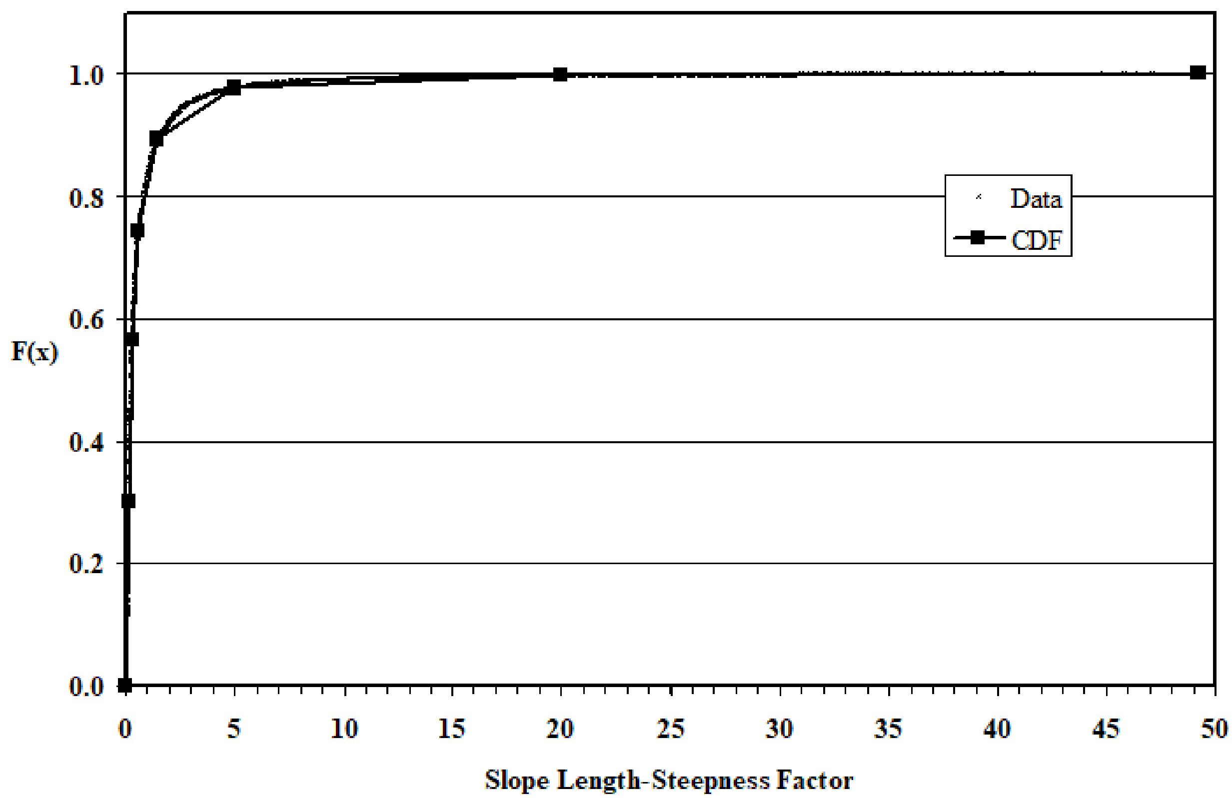

Figure C-19 Slope Length-Steepness Factor Cumulative Distribution Function

C.3.19 Cover and Management Factor

Applicable Code: RESRAD-OFFSITE

Description: The cover and management factor accounts for the effect of planting practices, crop rotations, management of crop residue, and canopy protection on soil erosion at the contaminated area.

Units: no units

Probabilistic Input:

Distribution: continuous linear

Defining Values for Distribution: See Table C-24 for the input values.

Discussion: The cover and management factor (*C*) is part of the USLE, discussed previously in Section C.3.16. As incorporated into RESRAD-OFFSITE, the USLE estimates the amount of soil erosion that occurs in the primary contamination area. The soil erosion rate is used to estimate surface soil concentrations in the primary contamination area. These concentrations are used to estimate the release of radionuclide contaminants to the atmosphere and groundwater and are also used to calculate inhalation and soil ingestion doses to onsite receptors. The amount of contaminants released to the atmosphere is used to estimate the accumulation of the radionuclides downwind in the agricultural and livestock feed areas.

Table C-24 Cumulative Distribution for the Cover and Management Factor

Cover and Management Factor	Cumulative Probability
0.00001	3.17E-06
0.020	0.327
0.085	0.421
0.149	0.519
0.284	0.845
0.400	0.961
0.550	0.991
1.00	1.00

Cover and management effects are closely intertwined because the type of cover present is dependent on how the land is managed. Crops can be grown in rotation, continuously, or the land can be laid fallow between crops. Seed bed preparation can involve various levels of previous crop or other plant residue left on the surface and various degrees of surface roughness due to tillage. Harvesting will also leave a certain amount of residue on the surface until the field is prepared for the next crop. Land may also be unmanaged and consist of open or forested areas.

The cover and management factor accounts for these effects and is defined as the ratio of soil loss from land cropped under certain conditions with the corresponding loss from clean-tilled continuous fallow conditions (Wischmeier and Smith 1978). Table C-25 and Table C-26 present suggested values for the cover and management factor for pasture areas and forest land, respectively. More details on estimating this factor for farmed areas can be found in Wischmeier and Smith (1978) and Renard et al. (1997).

The NRCS of the USDA has published the 1997 National Resources Inventory (USDA 2001), which contains a database with records for over 800,000 locations within the United States. Each record contains values for the parameters in the USLE. Because the database is designed for the statistical analysis of general conditions and trends involving soil, water, and related resources, individual farms and fields are not identified. From these data, a default distribution for the cover and management factor has been developed for RESRAD-OFFSITE that provides a national coverage. The distribution is listed in Table C-24 and shown in Figure C-20. The appropriate value or distribution of values for a site-specific cover and management factor are best determined in consultation with the expert at your local state agricultural extension office.

Table C-25 Cover and Management: Factor (C) for Permanent Pasture, Range, and Idle Land

Vegetative Canopy		Cover that Contacts the Soil Surface[a]						
		Percent Ground Cover						
Type and Height[b]	Percent Cover[c]	Type[d]	0	20	40	60	80	95+
No appreciable canopy		G	.45	.20	.10	.042	.013	.003
		W	.45	.24	.15	.091	.043	.011
Tall weeds or short brush, with average drop fall height of 20 in.	25	G	.36	.17	.09	.038	.013	0.003
		W	.36	.20	.13	.083	.041	.011
	50	G	.26	.13	.07	.035	0.012	.003
		W	.26	.16	.11	.076	.039	.011
	75	G	.17	.10	.06	.032	.011	.003
		W	.17	.12	.09	.068	.038	.011
Appreciable brush or bushes, with average drop fall height of 6.5 ft.	25	G	.40	.18	.09	.040	.013	.003
		W	.40	.22	.14	.087	.042	.011
	50	G	.34	.16	.08	.038	.012	.003
		W	.34	.19	.13	.082	.041	.011
	75	G	.28	.14	.08	.036	.012	.003
		W	.28	.17	.12	.078	.040	.011
Trees, but no appreciable low brush, with average drop fall height of 13 ft.	25	G	.42	.19	.10	.041	.013	.003
		W	.42	.23	.14	.089	.042	.011
	50	G	.39	.18	.09	.040	.013	.003
		W	.39	.21	.14	.087	.042	.011
	75	G	.36	.17	.09	.039	.012	.003
		W	.36	.20	.13	.084	.041	.011

[a] The listed C values assume that the vegetation and mulch are randomly distributed over the entire area.

[b] Canopy height is measured as the average fall height of water drops falling from the canopy to the ground. Canopy effect is inversely proportional to drop fall height and is negligible if fall height exceeds 33 ft.

[c] Portion of total-area surface that would be hidden from view by the canopy in a vertical projection (a birds-eye view).

[d] G: cover at surface is grass, grass like plants, decaying compacted duff, or litter at least 2 in. deep

[e] W: cover at surface is mostly broadleaf herbaceous plants (as weeds with little lateral-root network near the surface) or undecayed residues or both.

Source: Wischmeier and Smith (1978).

Table C-26 Cover and Management: Factor (C) for Undisturbed Forest Land

Percent of Area Covered by Canopy of Trees and Undergrowth	Percent of Area Covered by Duff at Least 2 in. Deep	Factor C[b]
100-75	100-90	.0001-.001
70-45	85-75	.002-.004
40-20	70-40	.003-.009

[a] Where effective litter cover is less than 40 percent or canopy cover is less than 20 percent, use Table C.3.19-2. Also, use Table C.3.19-2, where woodlands are being grazed, harvested, or burned.

[b] The ranges in listed C values are caused by the ranges in the specified forest litter and canopy covers and by variations in effective canopy heights.

Source: Wischmeier and Smith (1978).

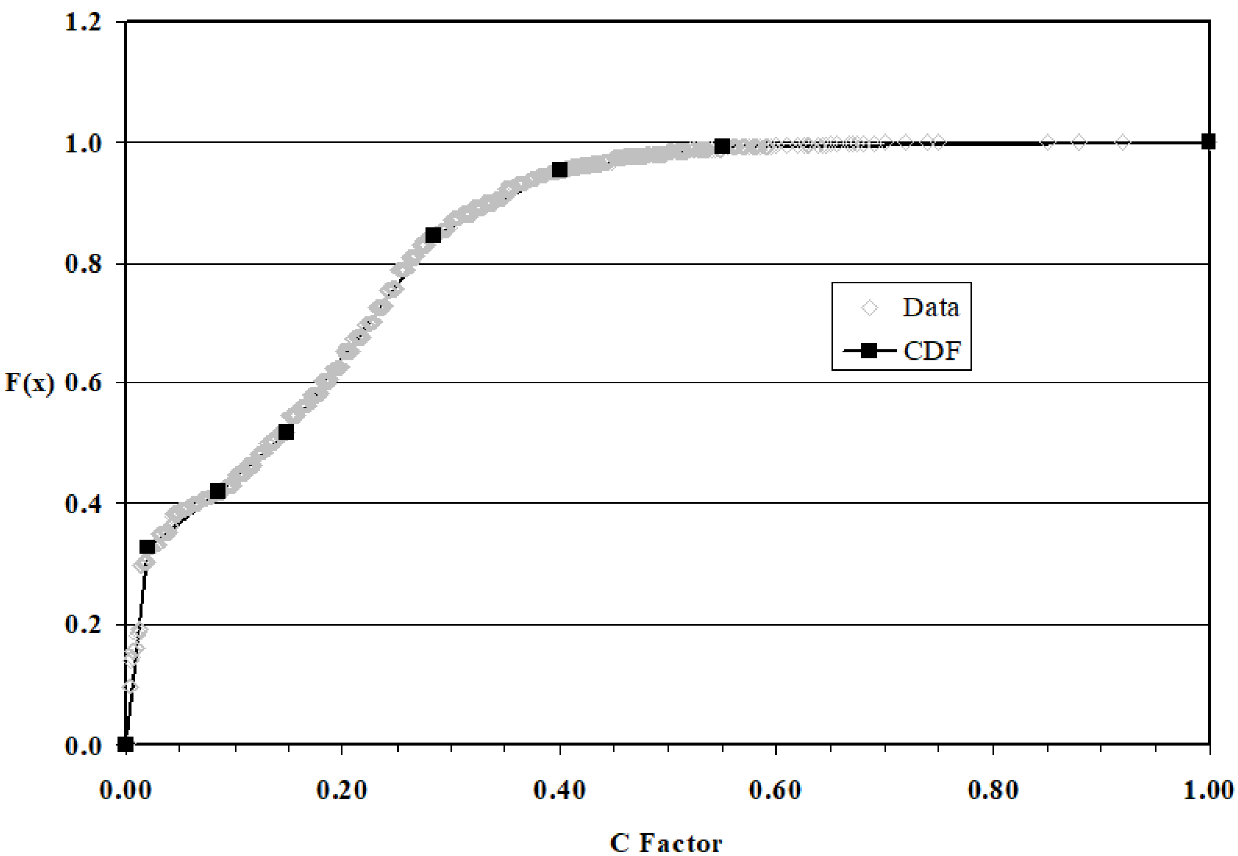

Figure C-20 Cover and Management Factor Cumulative Distribution Function

C.3.20 Support Practice Factor

Applicable Code: RESRAD-OFFSITE

Description: The support practice factor accounts for the effect of contouring, strip cropping, and terracing on soil erosion at the contaminated area.

Units: no units

Probabilistic Input:

Distribution: continuous linear

Defining Values for Distribution: See Table C-27 for the input values.

Discussion: The support practice factor (*P*) is part of the USLE, discussed previously in Section C.3.16. As incorporated into RESRAD-OFFSITE, the USLE estimates the amount of soil erosion that occurs in the primary contamination area. The soil erosion rate is used to estimate surface soil concentrations in the primary contamination area. These concentrations are used to estimate the release of radionuclide contaminants to the atmosphere and groundwater and are also used to calculate inhalation and soil ingestion doses to onsite receptors. The amount of contaminants released to the atmosphere is used to estimate the accumulation of the radionuclides downwind in the agricultural and livestock feed areas.

The support practice factor is defined as the ratio of soil loss with a specific support practice to the corresponding loss with upslope and downslope tillage (Wischmeier and Smith 1978). Thus, the support practice factor equals a value of 1.0 for crop rows running straight up-and-down a slope. Specific support practices include contouring, strip cropping, or terracing. Crop rotations, the amount of plant residue material, and other tillage practices are not considered here because these practices are considered as part of the cover and management factor (Section C.3.19).

Table C-27 Cumulative Distribution for the Support Practice Factor

Support Practice Factor	Cumulative Probability
0.25	0.00170
0.45	0.00821
0.55	0.0379
0.6	0.0604
0.75	0.0715
0.99	0.0782
1.00	1.00

Tillage and planting on the contour has shown to be the most effective on slopes in the 3 to 8 percent range (Wischmeier and Smith 1978). For smaller slopes, the land slope approaches the contour slope, and for larger slopes, the contour row capacity decreases. The slope length has an impact on the effectiveness of contouring because of water detention characteristics (infiltration and surface capacity) during precipitation events. If contour rows are breached by excess water, more soil could be lost than if the rows are oriented up and down the slope to carry the water away. Table C-28 lists some approximate support practice factors depending on land slope percent and slope length. Table C-29 lists values for the support practice factor when strip cropping is employed. Strip cropping, a practice that is more effective than contouring alone, involves alternating strips of sod and row crops or small grains on the contour. Terracing can further reduce erosion and can be combined with other practices, such as those considered with the cover and management factor (Section C.3.19). More details on estimating this factor for farmed areas can be found in Wischmeier and Smith (1978) and Renard et al. (1997).

Table C-28 Support Practice Factor: (P) Values and Slope-Length Limits for Contouring

Land Slope Percent	(P) Value	Maximum Length (ft.)[a]
1 to 2	0.60	400
3 to 5	0.50	300
6 to 8	0.50	200
9 to 12	0.60	120
13 to 16	0.70	80
17 to 20	0.80	60
21 to 25	0.90	50

[a] Limit may be increased by 25 percent if residue cover after crop seedlings will regularly exceed 50 percent.
Source: Wischmeier and Smith (1978).

Table C-29 Support Practice Factor: (P) Values, Maximum Strip Widths, and Slope-Length Limits for Contour Stripcropping

Land Slope Percent	P Values[a]			Strip Width (ft.)[b]	Maximum Length (ft.)
	A	B	C		
1 to 2	0.30	0.45	0.60	130	800
3 to 5	0.25	0.38	0.50	100	600
6 to 8	0.25	0.38	0.50	100	400
9 to 12	0.30	0.45	0.60	80	240
13 to 16	0.35	0.52	0.70	80	160
17 to 20	0.40	0.60	0.80	60	120
21 to 25	0.45	0.68	0.90	50	100

[a] P values: A is for 4-year rotation of row crop, small grain with meadow seedings, and 2 years of meadow. A second row crop can replace the small grain if meadow is established in it. B is for 4-year rotation of 2 years row crop, winter grain with meadow seeding, and 1-year meadow. C is for alternate strips of row crop and small grain.
[b] Adjust strip-width limit, generally downward, to accommodate widths of farm equipment.
Source: Wischmeier and Smith (1978).

The NRCS of the USDA has published the 1997 National Resources Inventory (USDA 2001), which contains a database with records for over 800,000 locations within the United States. Each record contains values for the parameters in the USLE. Because the database is designed for the statistical analysis of general conditions and trends involving soil, water, and related resources, individual farms and fields are not identified. From this data, a default distribution for the support practice factor has been developed for RESRAD-OFFSITE that provides a national coverage. The distribution is listed in Table C-27 and shown in Figure C-21. The appropriate value or distribution of values for a site-specific support practice factor is best determined in consultation with the expert at your local state agricultural extension office.

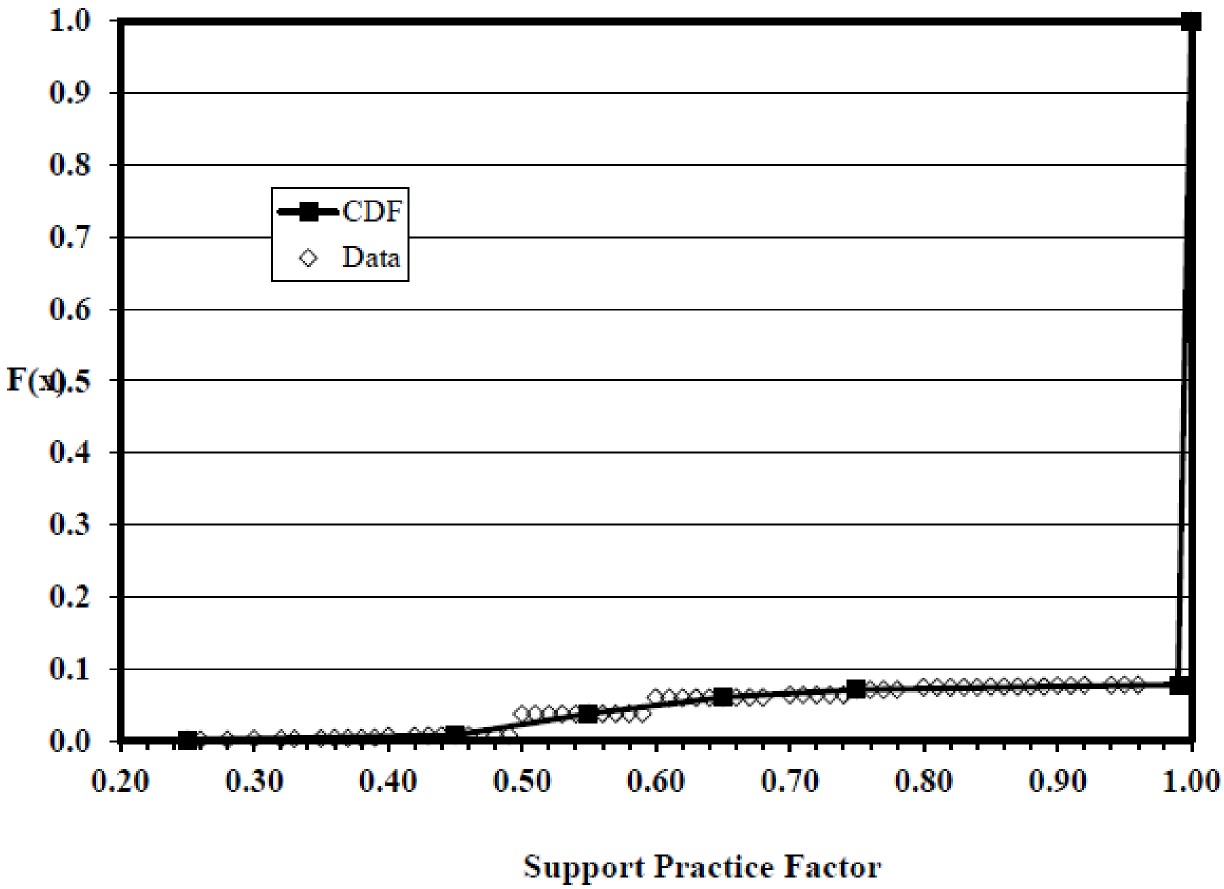

Figure C-21 Support Practice Factor Cumulative Distribution Function

C.3.21 C-14 Evasion Layer Thickness in Soil

Applicable Code: RESRAD-ONSITE and RESRAD-OFFSITE

Description: This parameter represents the maximum soil thickness layer through which carbon-14 (C-14) can escape to the air by conversion to carbon dioxide (CO_2).

Units: meters (m)

Probabilistic Input:

Distribution: triangular

Defining Values for Distribution:

Minimum: 0.2 Maximum: 0.6 Most likely: 0.3

Discussion: One of the important pathways involving the radiological dose to humans from soil contaminated with C-14 is the plant ingestion pathway. In addition to direct root uptake from soil and foliar deposition of dust particles contaminated with C-14, carbon in gases volatilized from the soil is directly incorporated into the plant by the process of photosynthesis.

Inorganic and organic reactions convert most forms of soil carbon to CO_2. Because of the volatile nature of CO_2, soil carbon is usually lost to the air, where it becomes absorbed in plants through photosynthesis. The concentration of C-14 in air above a contaminated zone depends on the volatilization (evasion) rate of carbon from the soil, the size and location of the source area, and meteorological dispersion conditions.

Sheppard et al. (1991) measured the rate of C-14 loss from soils in outdoor lysimeter experiments and investigated the vertical mobility of representative inorganic and organic C-14-labeled compounds in unsaturated soil for both net-leaching and net-capillary rise scenarios. The two chosen soils (one retentive and other with low retention) allowed investigation of the importance of organic matter and native carbonate content on C-14 mobility. The retentive soil was very fine sandy loam with high carbonate content, and the low retention acidic soil had no carbonate content (medium sand). Sheppard et al. (1991) observed upward movement of C-14 (perhaps linked to volatilization) up to the depth of 60 cm for the low retention acidic soil. Some upward movement was observed in all soil samples analyzed (activity ratio for the upward movement of 20 cm was >0.2). Amiro et al. (1991) assumed evasion layer thickness of 0.3 m in estimating C-14 flux from soil to the atmosphere.

On the basis of the above information, C-14 evasion layer thickness is assigned triangular distribution, with minimum of 0.2 m, a maximum value of 0.6 m, and a most likely value of 0.3 m. The probability density function is shown in Figure C-22.

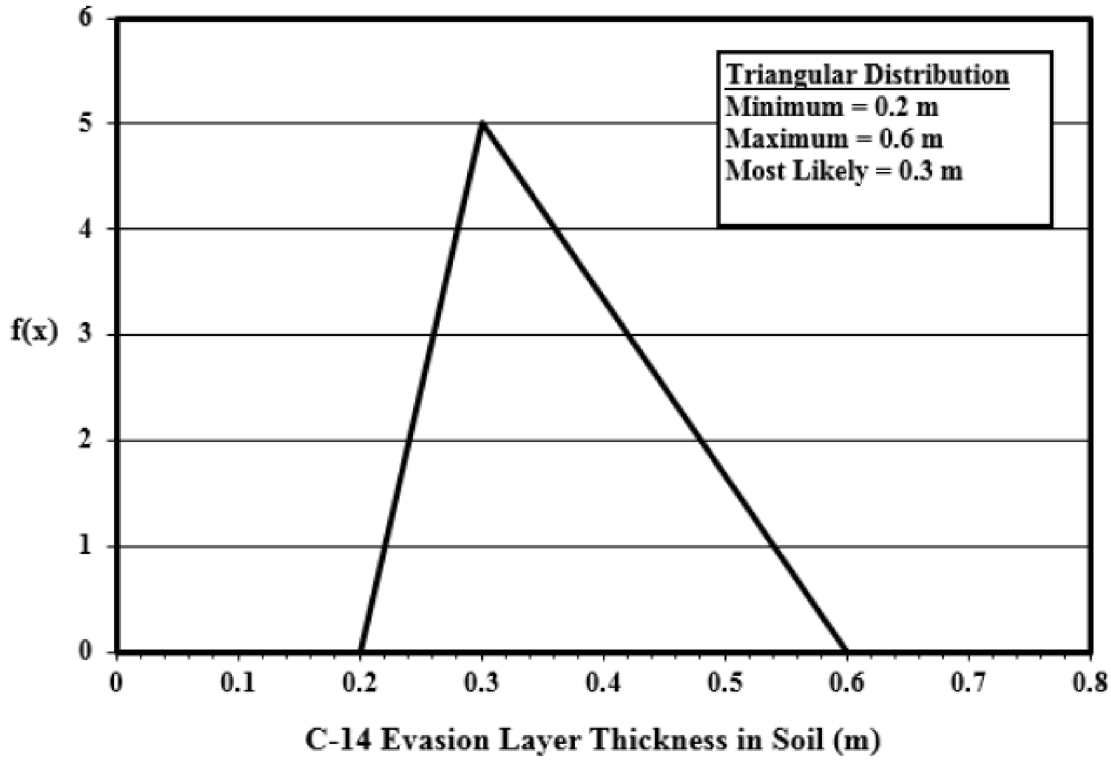

Figure C-22 Well Pump Intake Depth Probability Density Function

C.3.22 Sediment Distribution Coefficient

Applicable Code: RESRAD-OFFSITE

Description: The distribution coefficient is defined as the equilibrium ratio between the mass density of an element sorbed on a solid phase and its mass density in the liquid phase.

Units: cubic centimeters per gram (cm3/g) or liters per kilogram (L/kg)

Probabilistic Input:

Distribution: lognormal

Defining Values for Distribution: Values are assigned according to the element of the radioactive isotope as given in Table C-30.

Discussion: The surface water model in RESRAD-OFFSITE requires freshwater sediment K_d values for suspended particulates as well as for deposited particulates. The mass balance of radionuclides in surface water body depends on radionuclides in three phases, dissolved in water, sorbed on suspended particulates, and sorbed on recent (shallow) bed sediment.

The sediment K_d geometric mean ranges from recent literature search for 60 elements in freshwater environment are listed in Table C-30. Tables C-.31 and C-32 provide the values and distributions of sediment K_d in freshwater environment for suspended particulates and deposited particulates, respectively. The values are listed for different solid-liquid exchange conditions (field measurement, adsorption studies, and desorption studies), when available.

The sediment K_d for each radionuclide depends on many parameters, including sediment type and concentration, radionuclide state and concentration, the flow characteristics and water quality of a receiving surface water body, and contact time. Many geochemical conditions (e.g., pH, temperature, conductivity) influence the complexation and oxidation sate of elements and control mechanisms such as dissolution and precipitation, adsorption/desorption, and ion exchange. The site-specific sediment K_d values should be used.

Table C-30 Sediment K_d Geometric Mean Range from Literature Review

Element	Geometric Mean (cm^3/g or L/Kg)	Reference
Ag	5.25E+02 – 4.85E+05	Boyer et al. 2018
Al	4.62E+06	Boyer et al. 2018
Am	5.00E+03 – 2.20E+05	Boyer et al. 2018, Till and Meyer 1983
As	4.26E+03 – 1.63E+04	Boyer et al. 2018
B	1.41E+03	Boyer et al. 2018
Ba	3.95E+02 – 8.13E+03	Boyer et al. 2018
Be	3.87E+04 – 1.60E+05	Boyer et al. 2018
Ca	1.38E+02 – 1.35E+03	Boyer et al. 2018
Cd	3.29E+02 – 6.78E+04	Boyer et al. 2018
Ce	1.00E+04 – 1.81E+05	Boyer et al. 2018, Till and Meyer 1983
Cl	2.40E+01 – 9.80E+01	Sheppard et al. 2009
Cm	5.00E+03 – 1.64E+05	Boyer et al. 2018, Till and Meyer 1983
Co	8.55E+01 – 1.10E+06	Boyer et al. 2018, Till and Meyer 1983, Sheppard et al. 2009
Cr	1.76E+04 – 1.10E+05	Boyer et al. 2018, Sheppard et al. 2009
Cs	1.00E+03 – 1.00E+05	Boyer et al. 2018, Till and Meyer 1983, Sheppard et al. 2009
Cu	7.28E+03 – 3.26E+04	Boyer et al. 2018
Dy	5.80E+05	Boyer et al. 2018
Er	4.85E+05	Boyer et al. 2018
Eu	5.00E+02 – 2.10E+05	Boyer et al. 2018, Till and Meyer 1983
Fe	3.28E+03 – 3.20E+05	Boyer et al. 2018, Till and Meyer 1983, Sheppard et al. 2009
Gd	4.26E+05	Boyer et al. 2018
H	0.00E+00	Till and Meyer 1983
Hf	1.93E+06	Boyer et al. 2018
Ho	4.30E+04 – 4.25E+05	Boyer et al. 2018, Sheppard et al. 2009
I	1.0E+01 – 1.60E+04	Boyer et al. 2018, Till and Meyer 1983, Sheppard et al. 2009
K	1.93E+03	Boyer et al. 2018

Table C-30 Sediment K_d Geometric Mean Range from Literature Review (cont.)

Element	Geometric Mean (cm^3/g or L/Kg)	Reference
La	6.10E+04 – 1.03E+06	Boyer et al. 2018, Sheppard et al. 2009
Li	7.60E+03	Boyer et al. 2018
Mg	1.33E+02 – 1.63E+03	Boyer et al. 2018
Mn	8.20E+02 – 1.33E+06	Boyer et al. 2018, Till and Meyer 1983, Sheppard et al. 2009
Mo	7.27E+01 – 1.20E+04	Boyer et al. 2018, Sheppard et al. 2009
Na	6.07E+03	Boyer et al. 2018
Nb	1.00E+04 – 2.70E+05	Sheppard et al. 2009
Nd	5.20E+04 – 8.70E+05	Sheppard et al. 2009
Ni	1.03E+03 – 1.86E+04	Boyer et al. 2018, Sheppard et al. 2009
Np	1.00E+01	Sheppard et al. 2009
Pb	4.18E+04 – 5.40E+05	Boyer et al. 2018, Sheppard et al. 2009
Pm	5.00E+03	Till and Meyer 1983
Po	1.02E+05 – 8.42E+05	Boyer et al. 2018
Pr	1.21E+05	Boyer et al. 2018
Pu	6.04E+04 – 3.00E+05	Boyer et al. 2018, Till and Meyer 1983, Sheppard et al. 2009
Ra	5.00E+02 – 1.18E+04	Boyer et al. 2018, Till and Meyer 1983, Sheppard et al. 2009
Rb	7.33E+03	Boyer et al. 2018
Ru	2.73E+04 – 5.28E+04	Boyer et al. 2018
S	1.33E+03	Boyer et al. 2018
Sb	3.90E+03 – 2.40E+04	Boyer et al. 2018, Sheppard et al. 2009
Se	4.70E+02 – 1.54E+04	Boyer et al. 2018, Sheppard et al. 2009
Si	5.79E+03	Boyer et al. 2018
Sm	5.40E+04 – 4.30E+05	Sheppard et al. 2009
Sn	6.60E+03 – 1.33E+05	Boyer et al. 2018
Sr	5.01E+01 – 2.96E+03	Boyer et al. 2018, Till and Meyer 1983, Sheppard et al. 2009
Tc	0 – 5.00E+00	Till and Meyer 1983, Sheppard et al. 2009
Th	7.4E+02 – 1.90E+05	Boyer et al. 2018, Till and Meyer 1983, Sheppard et al. 2009
Ti	4.07E+04 – 1.05E+05	Boyer et al. 2018
Tm	3.90E+04 – 2.20E+05	Sheppard et al. 2009
U	1.60E+01 – 1.50E+04	Boyer et al. 2018, Till and Meyer 1983, Sheppard et al. 2009
V	3.71E+04 – 4.29E+04	Boyer et al. 2018
Yb	4.20E+04 – 3.50E+05	Sheppard et al. 2009
Zn	1.49E+02 – 7.20E+04	Boyer et al. 2018, Till and Meyer 1983
Zr	1.00E+03	Till and Meyer 1983

Table C-31 Sediment K_d Values and Distributions for Suspended Solids Under Different Conditions

Element	Condition	Geometric Mean (cm^3/g or L/kg)	Geometric Standard Deviation	Minimum (cm^3/g or L/kg)	Maximum (cm^3/g or L/kg)
Ag	Adsorption	8.30E+04	2.28	1.21E+04	1.58E+06
Ag	Desorption	4.10E+05	1.73	5.97E+04	9.48E+05
Ag	Field	4.85E+05	NR	1.08E+05	1.26E+06
Al	Field	4.62E+06	NR	4.62E+06	2.75E+08
Am	Field	7.94E+04	6.25	1.10E+03	1.31E+06
As	Field	1.63E+04	2.88	9.32E+01	2.36E+05
B	Field	1.41E+03	2.56	4.42E+02	6.20E+03
Ba	Adsorption	1.75E+03	3.18	7.20E+02	5.74E+03
Ba	Field	7.95E+03	2.75	8.48E+02	7.84E+04
Be	Adsorption	1.60E+05	NR	1.60E+05	3.60E+05
Be	Field	3.87E+04	2.59	2.20E+03	2.00E+05
Ca	Field	1.35E+03	1.44	4.12E+02	5.50E+03
Cd	Field	6.78E+04	2.07	1.65E+03	2.40E+05
Ce	Adsorption	1.81E+05	NR	5.30E+04	9.21E+05
Ce	Field	1.66E+05	1.87	7.25E+04	1.50E+06
Cm	Field	1.01E+05	NR	5.25E+04	2.88E+05
Co	Adsorption	8.76E+04	13.8	2.79E+02	1.13E+07
Co	Desorption	1.10E+06	5.05	1.20E+04	1.54E+07
Co	Field	4.43E+04	2.47	3.70E+03	9.26E+05
Cr	Field	6.87E+04	1.74	1.23E+03	6.10E+05
Cs	Adsorption	1.71E+04	2.47	1.25E+03	1.37E+05
Cs	Desorption	3.30E+04	2.5	4.36E+03	1.38E+05
Cs	Field	1.35E+05	2.67	2.34E+03	2.70E+06
Cu	Field	3.26E+04	2.19	1.05E+02	9.59E+06
Fe	Field	1.57E+05	2.74	2.41E+03	3.51E+06
I	Adsorption	3.62E+03	4.17	1.70E+02	1.05E+05
I	Field	3.32E+03	1.34	7.88E+02	4.64E+03
K	Field	1.93E+03	2.14	8.60E+02	1.01E+04
La	Field	1.36E+05	1.69	7.01E+04	4.09E+05
Mg	Field	1.63E+03	1.64	8.45E+01	4.69E+03
Mn	Adsorption	2.39E+05	9.75	3.73E+03	2.01E+07
Mn	Desorption	1.33E+06	6.33	2.70E+04	1.00E+07
Mn	Field	7.21E+04	3.15	1.63E+03	2.20E+08
Mo	Field	6.07E+03	3.09	8.08E-01	7.11E+06
Na	Field	1.53E+03	1.48	4.37E+02	4.29E+03
Ni	Field	1.86E+04	3.77	8.69E+02	5.40E+05

Note: NA—only one value available, NR—GSD not calculated because less than 10 values were available. Log normal distribution if more than 10 values were available.
Source: Boyer et al. 2018

Table C-31 Sediment K_d Values and Distributions for Suspended Solids Under Different Conditions (cont.)

Element	Condition	Geometric Mean (cm^3/g or L/kg)	Geometric Standard Deviation	Minimum (cm^3/g or L/kg)	Maximum (cm^3/g or L/kg)
Pb	Field	2.63E+05	2.3	1.14E+04	1.66E+07
Po	Field	8.42E+05	28.7	6.60E+04	2.58E+07
Pr	Field	1.21E+05	1.77	5.37E+04	4.21E+05
Pu	Adsorption	6.04E+04	NR	6.00E+03	3.00E+06
Pu	Field	1.47E+05	13.9	2.00E+02	1.60E+07
Ra	Adsorption	1.18E+04	NR	6.30E+03	2.42E+04
Ra	Field	5.21E+03	2.76	1.13E+02	1.73E+05
Rb	Field	7.33E+03	1.92	2.12E+03	2.38E+04
Ru	Field	2.73E+04	1.67	4.00E+02	5.39E+04
S	Field	1.33E+03	1.55	7.25E+02	7.06E+03
Sb	Adsorption	6.75E+03	2.73	8.00E+02	4.00E+04
Sb	Field	8.14E+03	2.64	3.40E+01	1.03E+05
Se	Field	1.54E+04	2.19	5.41E+03	6.65E+04
Si	Field	5.79E+03	1.88	2.42E+03	1.25E+04
Sn	Field	1.33E+05	1.59	3.72E+04	3.41E+05
Sr	Adsorption	1.42E+03	1.34	4.80E+02	2.48E+03
Sr	Field	2.96E+03	3.79	1.11E+02	1.99E+04
Th	Field	1.52E+05	2.9	1.13E+04	1.60E+06
Ti	Field	1.05E+05	1.35	2.41E+04	1.58E+05
U	Field	1.19E+04	5.63	3.05E+02	1.27E+05
V	Field	4.29E+04	1.4	1.19E+04	8.46E+04
Zn	Field	7.20E+04	2.68	3.00E+03	3.32E+07

Note: NA—only one value available, NR—GSD not calculated because less than 10 values were available. Log normal distribution if more than 10 values were available.
Source: Boyer et al. 2018

Table C-32 Sediment K_d Values and Distributions for Dissolved Solids Under Different Conditions

Element	Condition	Geometric Mean (cm^3/g or L/kg)	Geometric Standard Deviation	Minimum (cm^3/g or L/kg)	Maximum (cm^3/g or L/kg)
Ag	Field	5.25E+02	NA	NA	NA
Am	Adsorption	2.20E+05	3.81	2.70E+03	2.25E+06
As	Field	4.26E+03	3.47	6.50E+01	2.93E+04
Ba	Field	8.13E+03	NR	8.13E+03	1.05E+04
Ba	Adsorption	3.95E+02	NR	4.50E+01	5.50E+02
Ca	Field	1.38E+02	NR	5.42E+01	1.47E+03
Cd	Field	3.29E+02	6.48	7.69E+01	1.50E+04
Cm	Adsorption	1.64E+05	6.81	1.00E+04	2.25E+06
Co	Adsorption	1.59E+04	10.4	2.00E+01	5.43E+05
Co	Desorption	1.57E+04	65	6.76E+01	2.50E+06
Co	Field	8.55E+01	28.3	2.00E+00	1.40E+05
Cr	Field	1.76E+04	14.3	2.92E+02	1.29E+05
Cs	Adsorption	4.97E+03	9.74	9.92E+00	6.06E+04
Cs	Desorption	1.35E+04	5.67	8.37E+02	2.10E+05
Cs	Field	6.66E+03	3.91	7.25E+02	2.47E+05
Cu	Field	7.28E+03	21.4	4.40E+00	2.94E+05
Dy	Field	5.80E+05	2.53	4.07E+04	3.66E+06
Er	Field	4.85E+05	2.24	4.28E+04	3.24E+06
Eu	Field	2.10E+05	2.18	2.69E+04	6.52E+05
Fe	Field	3.28E+03	69.1	1.05E+01	5.00E+06
Gd	Field	4.26E+05	3.16	3.51E+04	4.35E+06
Hf	Field	1.93E+06	1.77	3.77E+05	6.11E+06
Ho	Field	4.25E+05	1.97	3.98E+04	1.16E+06
I	Adsorption	1.93E+01	17.4	7.47E-02	4.00E+03
La	Field	1.03E+06	2.49	3.72E+04	1.80E+07
Li	Field	7.60E+03	2.08	9.32E+01	5.01E+04
Mg	Field	1.33E+02	NR	6.25E+01	3.04E+02
Mn	Adsorption	5.50E+03	50.3	5.33E+01	1.64E+06
Mn	Desorption	5.94E+03	NR	1.87E+03	1.64E+06
Mn	Field	2.97E+04	11.3	3.70E+02	3.42E+06
Mo	Field	7.27E+01	NR	4.16E+01	2.69E+02
Ni	Field	1.03E+03	5.99	1.87E+01	5.67E+04
Pb	Field	4.18E+04	14.9	3.33E+01	5.60E+06
Po	Field	1.02E+05	5.35	2.21E+04	6.10E+06
Pu	Adsorption	6.49E+04	2.78	9.30E+03	4.20E+05
Pu	Desorption	2.96E+05	2.05	3.07E+04	1.25E+07
Ra	Adsorption	8.18E+03	1.3	5.63E+03	2.42E+04

Note: NA—only one value available, NR—GSD not calculated because less than 10 values were available. Log normal distribution if more than 10 values were available.
Source: Boyer et al. 2018

Table C-32 Sediment K_d Values and Distributions for Dissolved Solids Under Different Conditions (cont.)

Element	Condition	Geometric Mean (cm^3/g or L/kg)	Geometric Standard Deviation	Minimum (cm^3/g or L/kg)	Maximum (cm^3/g or L/kg)
Ra	Field	1.20E+03	23.9	8.24E+01	1.67E+05
Ru	Adsorption	5.28E+04	1.39	3.34E+04	7.90E+04
Sb	Field	1.20E+04	NR	1.09E+04	1.94E+04
Se	Field	7.08E+03	NA	NA	NA
Sr	Adsorption	5.01E+01	3.21	2.84E+00	1.34E+03
Sr	Desorption	4.81E+02	2.23	3.46E+01	2.06E+03
Sr	Field	1.38E+02	NA	6.00E+00	3.45E+03
Th	Adsorption	1.56E+05	47.8	1.15E+02	2.75E+06
Th	Field	7.40E+02	NA	3.60E+02	4.72E+05
Ti	Field	4.07E+04	NA	NA	NA
U	Field	3.50E+03	40.1	9.10E+01	8.04E+04
V	Field	3.71E+04	NA	NA	NA
Zn	Field	1.49E+02	32.4	2.11E+00	1.71E+04

Note: NA—only one value available, NR—GSD not calculated because less than 10 values were available. Log normal distribution if more than 10 values were available.
Source: Boyer et al. 2018

C.4 Meteorological Parameters

C.4.1 Precipitation Rate

Applicable Code: RESRAD-ONSITE and RESRAD-OFFSITE

Description: The precipitation rate is defined as the average volume of water in the form of rain, snow, hail, or sleet that falls per unit of area and per unit of time at the site.

Units: meters per year (m/yr)

Probabilistic Input:

Distribution: none recommended

Discussion: The precipitation rate, P_r, is used in the RESRAD-ONSITE and RESRAD-OFFSITE codes along with other input parameters, such as runoff coefficient, irrigation rate, and evapotranspiration coefficient, to determine the deep water percolation rate according to mass balance. The deep water percolation rate is ultimately used to calculate the radionuclide leaching rate of the contaminated zone and the subsequent contamination of the underlying groundwater system.

For a given site, the precipitation rate varies with time because the annual precipitation changes from year to year. Spatial variation within a site will be insignificant unless the area of the site is very large. Table C-33 gives the annual average precipitation (in inches) for the large cities in the United States (https://www.currentresults.com/Weather/US/average-annual-precipitation-by-city.php) based on the weather data collected from 1981 to 2010 for the NOAA National Climatic Data Center. The annual average precipitation is the sum of the arithmetic means for each month over the 30-year period and includes the liquid water equivalent of snowfall.

A national average precipitation rate distribution is not recommended because of the large variations in precipitation that occur across the United States. Even state precipitation rate distributions may not properly represent all relevant locations because of differences in climate caused by local topography. A deterministic value from the nearest weather station (https://www.ncdc.noaa.gov/cdo-web/datatools/normals) may be used as a starting point for risk analysis, but the precipitation rate is a site-specific parameter that should be characterized at a contaminated site before the appropriate remedial action(s) can be selected.

Table C-33 Precipitation Data for Large Cities in the United States (average inches per year for the period 1981–2010)

City	Annual Average Precipitation (in.)	City	Annual Average Precipitation (in.)
Atlanta, Georgia	49.7	Nashville, Tennessee	47.3
Austin, Texas	34.2	New Orleans, Louisiana	62.7
Baltimore, Maryland	41.9	New York, New York	49.9
Birmingham, Alabama	53.7	Oklahoma City, Oklahoma	36.5
Boston, Massachusetts	43.8	Orlando, Florida	50.7
Buffalo, New York	40.5	Philadelphia, Pennsylvania	41.5
Charlotte, North Carolina	41.6	Phoenix, Arizona	8.2
Chicago, Illinois	36.9	Pittsburg, Pennsylvania	38.2
Cincinnati, Ohio	41.9	Portland, Oregon	43.5
Cleveland, Ohio	39.1	Providence, Rhode Island	47.2
Columbus, Ohio	39.3	Raleigh, North Carolina	46
Dallas, Texas	37.6	Richmond, Virginia	43.6
Denver, Colorado	15.6	Riverside, California	10.3
Detroit, Michigan	33.5	Rochester, New York	34.3
Hartford, Connecticut	45.9	Sacramento, California	18.5
Houston, Texas	49.8	Salt Lake City, Utah	16.1
Indianapolis, Indiana	42.4	San Antonio, Texas	32.3
Jacksonville, Florida	52.4	San Diego, California	10.3
Kansas City, Missouri	39.1	San Francisco, California	20.7
Las Vegas, Nevada	4.2	San Jose, California	15.8
Los Angeles, California	12.8	Seattle, Washington	37.7
Louisville, Kentucky	44.9	St. Louis, Missouri	41
Memphis, Tennessee	53.7	Tampa, Florida	46.3
Miami, Florida	61.9	Virginia Beach, Virginia	46.5
Milwaukee, Wisconsin	34.8	Washington, DC	39.7
Minneapolis, Minnesota	30.6		

[a] To convert from inches to meters, multiply by 0.0254.
Source: National Climatic Data Center, NOAA’s 1981–2010 Climate Normals.
https://www.currentresults.com/Weather/US/average-annual-precipitation-by-city.php

C.4.2 Runoff Coefficient

Applicable Code: RESRAD-ONSITE and RESRAD-OFFSITE

Description: The average annual runoff coefficient is the fraction of the average annual precipitation that does not infiltrate into the soil and is not transferred back to the atmosphere through evapotranspiration. The runoff coefficient represents the fraction of the precipitation, in excess of the deep percolation and evapotranspiration, and becomes surface flow and ends up in either perennial or intermittent surface water bodies.

Units: no units

Probabilistic Input:

Distribution: uniform

Minimum: 0.1 Maximum: 0.8

Discussion: The runoff coefficient (C_r) is one of the input parameters used in RESRAD-OFFSITE to determine the water deep percolation rate according to mass balance at the primary contaminated area, the two agricultural areas (i.e., fruit, grain, and non-leafy vegetables and leafy vegetables), the two livestock-feed growing areas (pasture and silage, and grain), and the dwelling area. The water percolation rate in deep soil is ultimately used to calculate the radionuclide leaching rate from the topsoil in these areas and the subsequent contamination of the underlying groundwater system. RESRAD-ONSITE looks only at the percolation rate at the primary contaminated area.

The runoff rate at any specific location is influenced by the morphology of the region, the degree of the slopes, the type of soil material, and the type of soil utilization. The runoff coefficient varies with the frequency, the duration, and the magnitude of precipitation events. If the precipitation rate exceeds the hydraulic conductivity of the cover or contaminated zone, the excess will be removed by runoff, and the runoff coefficient will be increased. Thus, in addition to the factors considered in Table C-34, the average annual precipitation rate, the land coverage of urban environment, and the hydraulic conductivity of the unsaturated stratum exert an influence on the runoff coefficient.

Runoff curve numbers (CN_s) can be used to estimate the runoff coefficient for a particular site. The Soil Conservation Service (SCS) runoff curve number indicates runoff potential for a particular area on the basis of land use and hydrologic soil groups. In the past, SCS runoff curve numbers were produced by manually relating land uses and hydrologic soil types within particular areas and performing calculations. Now, by using the ARC/INFO UNION command, engineers can compute the SCS runoff curve number for the entire sub-basin based on the land use and hydrologic soil type (Robbins and Phipps, 1996).

The following equation gives the SCS relationship for estimating Q (depth of runoff) from P (rainfall) and S (Maidment, 1992).

$$Q = \frac{(P - 0.2\,S)^2}{P + 0.8\,S} \tag{C-20}$$

S is (1000/CN) - 10, and CN is the runoff curve number. The value of CN depends on the soil, cover, and hydrologic condition of the land surface. These conditions are described by Maidment (1992). The value of CN also depends on the antecedent moisture condition, which represents the degree of saturation of the soil prior to a rainfall event. Table C-35 provides the SCS runoff curve numbers for average antecedent moisture conditions. These values need to be modified for very dry and very wet conditions (Meyer et al., 1997). Standard values of *CN* for various land uses and soil types are given by Maidment (1992).

According to the SCS, if the soil has been disturbed but no significant compaction has occurred, the hydrologic soil group can be assigned based on soil texture as follows:

- Group A: Sand, loamy sand, or sandy loam;
- Group B: Silt loam or loam;
- Group C: Silt, Sandy clay loam; and
- Group D: Clay loam, silty clay loam, sandy clay, silty clay, or clay.

A uniform distribution has been assigned as input to RESRAD-ONSITE and RESRAD-OFFSITE for the runoff coefficient with minimum and maximum values of 0.1 and 0.8, respectively, as suggested by the data in Table C-34. These input data should be changed to reflect local site conditions when performing site-specific analyses. Figure C-23 displays the probability density function for the runoff coefficient.

Table C-34 Runoff Coefficient Values

Type of Area	Coefficient	Value
Agricultural environment[a]		
Flat land with average slopes of 0.3-0.9 m/mi	*C1*	0.3
Rolling land with average slopes of 4.6-6.1 m/mi	*C1*	0.2
Hilly land with average slopes of 46-76 m/mi	*C1*	0.1
Open sandy loam	*C2*	0.4
Intermediate combinations of clay and loam	*C2*	0.2
Tight, impervious clay	*C2*	0.1
Woodlands	*C3*	0.2
Cultivated lands	*C3*	0.1
Urban environment		
Flat, residential area C about 30 percent impervious	C_r	0.4
Moderately steep, residential area C about 50 percent impervious	C_r	0.65
Moderately steep, built-up area C about 70 percent impervious	C_r	0.8

[a] The runoff coefficient for an agricultural environment is given by $C_r = 1 - c1 - c2 - c3$.
Source: Gilbert et al. (1989).

Table C-35 SCS Runoff Curve Numbers for Average Antecedent Moisture Condition

Land Use or Cover	Hydrologic Condition[a]	Runoff Curve No. by Hydrologic Soil Group			
		A	B	C	D
Fallow		77	86	91	94
Pasture or range	Poor	68	79	86	89
	Fair	49	69	79	84
	Good	39	61	74	80
Contoured pasture or range	Poor	47	67	81	88
	Fair	25	59	75	83
	Good	6	35	70	79
Meadow		30	58	71	78
Woods	Poor	45	66	77	83
	Fair	36	60	73	79
	Good	25	55	70	77
Brush-brushwood grass mixture with brush the major element	Poor	48	67	77	88
	Fair	35	56	70	77
	Good	30	48	65	73
Woods-grass combination (orchard or tree farm)	Poor	57	70	82	86
	Fair	48	65	76	82
	Good	32	58	72	79
Roads (dirt)		72	82	87	89
Roads (hard surface)		74	84	90	92

[a] Poor = less than 50 percent ground cover, fair = 50-75 percent ground cover, good = greater than 75 percent ground cover.
Source: Meyer et al. (1997).

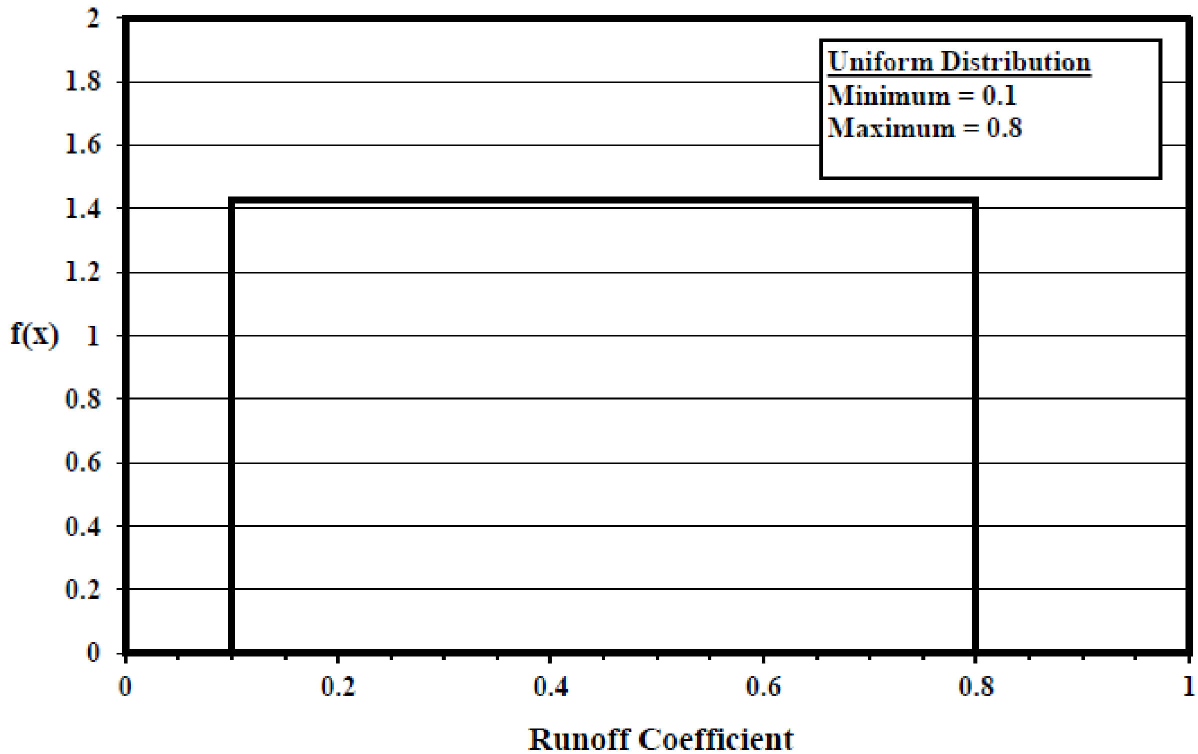

Figure C-23 Runoff Coefficient Probability Density Function

C.4.3 Evapotranspiration Coefficient

Applicable Code: RESRAD-ONSITE and RESRAD-OFFSITE

Description: The evapotranspiration coefficient is the ratio of the total volume of water vapor that is transferred to the atmosphere through evapotranspiration to the total volume of water available within the root zone of the soil.

Units: cubic centimeters per gram (cm3/g) or liters per kilogram (L/kg)

Probabilistic Input:

Distribution: no units

Defining Values for Distribution None recommended (see the discussion for estimating site-specific values).

Discussion: The evapotranspiration coefficient, C_e, can be expressed as:

$$C_e = \frac{ET_r}{(1 - C_r)\, P_r + IR_r} \tag{C-21}$$

ET_r is the evapotranspiration rate (m/yr); P_r is the precipitation rate (m/yr); IR_r is the irrigation rate (m/yr), and C_r is the runoff coefficient. This parameter and certain other input parameters, such as precipitation rate, irrigation rate, and the runoff coefficient, are used in RESRAD-

OFFSITE to determine the water deep percolation rate according to mass balance at the primary contaminated area, the two agricultural areas (i.e., fruit, grain, and non-leafy vegetables and leafy vegetables), the two livestock-feed growing areas (pasture and silage, and grain), and the dwelling area. The water percolation rate in deep soil is ultimately used to calculate the radionuclide leaching rate from the topsoil in these areas and the subsequent contamination of the underlying groundwater system. RESRAD-ONSITE looks only at the percolation rate at the primary contaminated area.

Evaporation is the process whereby liquid is converted to water vapor and removed from the evaporating surface (i.e., ground surface in this case). To change the state of the water molecules from liquid to vapor requires energy. Once water molecules evaporate, the difference of vapor pressure between the evaporating surface and the surrounding atmosphere would remove the water vapor from the evaporating surface. Hence, solar radiation, air temperature, air humidity, and wind speed are climatological parameters to consider when assessing the evaporation process. In addition, the degree of shading of the crop canopy and the amount of water available at the evaporating surface also need to be considered when the evaporating surface is the soil surface.

Transpiration consists of the vaporization of liquid water contained in plant tissues and the vapor removal to the atmosphere. Nearly all water taken up is lost by transpiration and only a tiny fraction is used within the plant. Transpiration, like direct evaporation, depends on the energy supply, vapor pressure gradient, and wind. In addition, the soil water content and the ability of the soil to conduct water to the roots also determine the transpiration rate, as does water logging and soil water salinity. Different kinds of plants may have different transpiration rates.

The type of crop, its development, its environment setting, and its field management should be considered when assessing transpiration.

Evaporation and transpiration occur simultaneously and there is no easy way of distinguishing them. When the crop is small, water is predominantly lost by soil evaporation, but once the crop is well developed and completely covers the soil, transpiration becomes the main process.

Evapotranspiration is the combination of evaporation from the soil surface and transpiration from vegetation. The evapotranspiration rate is normally expressed in length per unit time (e.g., mm/d and m/yr).

Owing to the difficulty of obtaining accurate field measurements, the evapotranspiration rate is commonly computed from weather data. Numerous equations have been developed by different researchers, but some of them are only valid under specific climatic and agronomic conditions. As a result of an Expert Consultation held in May 1990, the Food and Agriculture Organization (FAO) of the United Nations adopted the Penman-Monteith combination method to calculate the evapotranspiration rate for different types of crops under different growth and management conditions (Allen et al. 1998). The method involves the use of a reference evapotranspiration rate (ET_o) and a crop coefficient (K_c) to calculate the evapotranspiration rate for a specific crop (ET_c). The reference crop was defined as a hypothetical crop with an assumed height of 0.12 m, a surface resistance of 70 s/m, and an albedo of 0.23, closely resembling an extensive surface of green grass of uniform height, actively growing and adequately watered. ET_o is the evapotranspiration rate for the reference crop under standard, i.e., no stress, adequately watered, growing condition. K_c is a correction factor for ET_o and accounts for the aggregation of the physical and physiological differences between a specific crop and the reference crop. It can also include an adjustment to account for the deviation of actual growing condition from standard condition, such as water and salinity stress, low plant density, environmental factors, and management practices. The product of ET_o and K_c gives the value of ET_c.

Table C-36 lists the average values of ET_o in different agro-climatic regions. The value of ET_o is expressed in mm/d and accounts for daily evapotranspiration rate during the growing season. Table C-37 lists the crop coefficient K_c during different growing stages for different crops under standard conditions (Allen et al. 1998). The value of Kc during the middle growing stage, K_c, mid, is greater than that during the initial and developmental stages, K_c, ini, and that during the late growing stage, $K_{c,\text{end}}$, because in the middle growing stage, crop is fully grown and transpires more water through foliage. The seasonal $K_{c,\text{avg}}$, listed in the last column is either the weighted average of K_{cs} obtained by considering the duration of different growing stages, when information on the duration of different stages is available, or simply the average of K_{cs}, when information on the duration of different stages is missing. Table C-38 lists the ranges and mean values of K_c for the four different crop categories (leafy vegetables; fruit, grain, and non- leafy vegetables; forage; and grain) considered in RESRAD-OFFSITE during the growing season. They were obtained by aggregating the individual $K_{c,\text{avg}}$ over all the different crops listed under each crop category.

The values of K_c and $K_{c,\text{avg}}$ presented above are for standard growing conditions. In reality, the soil conditions in the field may differ from the standard conditions, because of unfavorable environmental settings or poor field manage K_c values by a stress coefficient K_s is necessary to account for the real situation. Although no simple and direct method is provided by FAO (Allen et al. 1998) for estimating K_s, in general, a value between 0.5 and 1 can be selected, with 0.5 representing very poor soil conditions and 1 representing excellent, desirable conditions.

Table C-36 Average ET_o (mm/d) for Different Agroclimatic Regions

Regions	**Mean Daily Temperature (°C)**		
	Cool ~10°C	**Moderate 20°C**	**Warm > 30°C**
Tropics and subtropics			
Humid and sub-humid	2–3	3–5	5–7
Arid and semi-arid	2–4	4–6	6–8
Temperate region			
Humid and sub-humid	1–2	2–4	4–7
Arid and semi-arid	1–3	4–7	6–9
Source: Allen et al. (1998), Table 2.			

Table C-37 Single (Time-Averaged) Crop Coefficient, $K_{c,avg}$, for Non-Stressed, and Well-Managed Crops

Crop	$K_{c,ini}$[a]	$K_{c,mid}$[b]	$K_{c,end}$[c]	Length of Crop Development Stages (d)					$K_{c,avg}$[d]
				Init. (L_{ini})	Dev. (L_{dev})	Mid (L_{mid})	Late (L_{late})	Total	
Fruits and nuts									
Apple, cherry, and pear	1	1	1	23[e]	63[e]	113[e]	40[e]	239	0.86
Apricot, peach, stone fruits	*0.58*[f]	*1.03*	*0.76*	23[e]	63[e]	113[e]	40[e]	239	0.82
Banana, year 1	0.5	1.1	1	120	90	120	60	390	0.76
Cantaloupe	0.5	0.85	0.6	20	52.5	30	17.5	120	0.6
Citrus fruits, no ground cover	*0.62*	*0.57*	*0.83*	60	90	120	95	365	0.66
Citrus fruits, active ground cover	*0.8*	*0.78*	*0.8*	60	90	120	95	365	0.79
Grape	0.3	0.78	0.45	22.5	50	81.25	55	209	0.53
Kiwi	0.4	1.05	1.05						0.83
Olive	0.65	0.7	0.7	30	90	60	90	270	0.68
Pineapple	0.5	0.4	0.4	60	120	600	10	790	0.42
Pistachio	0.4	1.1	0.45	20	60	30	40	150	0.58
Strawberry	0.4	0.85	0.75						0.67
Sweet melon	0.5	1.05	0.75	25	37.5	55	21.25	138.8	0.76
Watermelon	0.4	1	0.75	15	25	25	30	95	0.67
Walnut	0.5	1.1	0.65	20	10	130	30	190	0.93
Grain									
Barley	0.3	1.15	0.25	25	36.7	55.8	31.7	149	0.61
Maize, field (grain*; field corn*)	*0.3*	1.2	*0.48*	26	40	48	35	148	0.63
Maize, sweet (*sweet corn*)	*0.3*	1.15	1.05	22	29	31	29	111	0.73
Millet	*0.3*	1	0.3	18	28	48	30	123	0.57
Oat	0.3	1.15	0.25	25	36.7	55.8	31.7	149.2	0.61
Sorghum	0.3	1.13	0.8	20	35	42.5	30	127.5	0.69
Spring wheat	0.3	1.15	0.33	25	36.7	55.8	31.7	149.2	0.62
Winter wheat	0.55	1.15	0.33	131	272	61.7	28.3	493	0.61
Non-Leafy vegetables									
Artichoke	0.5	1	0.95	30	33	250	30	343	0.90
Asparagus	0.5	0.95	0.3	70	30	150	48	298	0.69
Bean, dry and pulses	0.4	1.15	0.35	*20*	*26.7*	*35*	*20*	101.7	0.65

[a] $K_{c,ini}$: K_c in the initial and developmental growing stages.
[b] $K_{c,mid}$: K_c in the middle growing stage.
[c] $K_{c,end}$: K_c in the late growing stage.
[d] $K_{c,avg}$: Average seasonal K_c value calculated by weighting K_c in a different growing stage with the duration of that growing stage, or by averaging the K_cs in a different growing stage, when the duration of different growing stages are not available.
[e] Values for deciduous orchard.
[F] Values in Italic font are the average of the reported range. Source: Allen et al. (1998), Tables 11 and 12.

Table C-37 Single (Time-Averaged) Crop Coefficient, $K_{c,avg}$, for Non-Stressed, and Well-Managed Crops (cont.)

Crop	$K_{c,ini}$[a]	$K_{c,mid}$[b]	$K_{c,end}$[c]	Length of Crop Development Stages (d)					$K_{c,avg}$[d]
				Init. (L_{ini})	Dev. (L_{dev})	Mid (L_{mid})	Late (L_{late})	Total	
Non-Leafy vegetables (cont.)									
Bean, green	0.5	1.05	0.9	*17.5*	*27.5*	*27.5*	*10*	82.5	0.73
Beets	0.5	1.05	0.95	*20*	*27.5*	*22.5*	*10*	80	0.71
Carrot	*0.7*	1.05	0.95	27	40	63	23	153	0.58
Cassava, year 1	*0.3*	0.8	0.3	20	40	90	60	210	0.51
Cassava, year 2	*0.3*	1.1	0.5	150	40	110	60	360	0.58
Chick pea	*0.4*	1	0.35						0.58
Cucumber	0.65	1	0.6	*22.5*	*32.5*	*45*	*17.5*	117.5	0.78
Eggplant	0.6	1.05	0.9	*30*	*42.5*	*40*	*22.5*	135	0.78
Fababean, fresh	0.5	1.15	1.1	90	45	40	0	175	0.65
Garlic	*0.7*	1	0.7						0.80
Grabanzo	0.4	1.15	0.35						0.63
Green gram and cowpea	*0.4*	1.05	0.48	20	30	30	20	100	0.61
Groundnut (peanut)	*0.4*	1.15	0.6	32	38	38	28	137	0.65
Lentil	*0.4*	1.1	0.3	23	33	65	40	160	0.66
Onion, green	*0.7*	1	1	25	43	28	18	115	0.41
Pea	*0.4*	*1.15*	*0.63*	23	27	33	17	100	0.69
Potato	0.5	1.15	0.75	31	32	*50.5*	27	140.5	0.78
Pumpkin	0.5	1	0.8	*22.5*	*32.5*	*32.5*	*22.5*	110	0.71
Radish	0.7	0.9	0.85	7.5	10	15	5	37.5	0.8
Soybean	*0.4*	1.15	0.5	18	13	58	23	113	0.81
Squash, zucchini	0.5	0.95	0.75	*22.5*	*32.5*	*25*	*15*	95	0.66
Sugar beet	0.35	1.2	0.7	*33.6*	*50*	*75.7*	*35.7*	195	0.74
Sweet pepper	0.6	1.05	0.9	*28.8*	*37.5*	*75*	*25*	166.3	0.85
Sweet potato	0.5	1.15	0.65	*17.5*	*30*	*55*	*35*	137.5	0.8
Tomato	0.6	1.15	0.8	31	41	53	29	154	0.83
Turnip	*0.5*	1.1	0.95						0.85
Leafy vegetables									
Broccoli	0.7	1.05	0.95	35	45	40	15	135	0.83
Brussel sprout	*0.7*	1.05	0.95	25	33	45	20	123	0.54
Cabbage	*0.7*	1.05	0.95	40	60	50	15	165	0.40
Cauliflower	0.7	1.05	0.95	35	50	40	15	140	0.83
Celery	0.7	1.05	1	*26.7*	*45*	*81.7*	*18.3*	171.7	0.90
Lettuce	0.7	1	0.95	*27.5*	*38.75*	*28.75*	10	105	0.81

[a] $K_{c,ini}$: K_c in the initial and developmental growing stages.
[b] $K_{c,mid}$: K_c in the middle growing stage.
[c] $K_{c,end}$: K_c in the late growing stage.
[d] $K_{c,avg}$: Average seasonal K_c value calculated by weighting K_c in a different growing stage with the duration of that growing stage, or by averaging the K_cs in a different growing stage, when the duration of different growing stages are not available.
[e] Values for deciduous orchard.
[f] Values in Italic font are the average of the reported range. Source: Allen et al. (1998), Tables 11 and 12.

Table C-37 Single (Time-Averaged) Crop Coefficient, $K_{c,avg}$, for Non-Stressed, and Well-Managed Crops (cont.)

Crop	$K_{c,ini}$[a]	$K_{c,mid}$[b]	$K_{c,end}$[c]	Length of Crop Development Stages (d)					$K_{c,avg}$[d]
				Init. (L_{ini})	Dev. (L_{dev})	Mid (L_{mid})	Late (L_{late})	Total	
Leafy vegetables (cont.)									
Spinach	*0.7*	1	0.95	20	25	20	8	73	0.37
Forage									
Alfalfa	0.4	0.88	0.85	*7.5*	*20*	*16.25*	*8.75*	52.5	0.62
Bermuda grass	0.45	0.95	0.75	10	25	35	35	105	0.72
Clover	*0.4*	*1.03*	*0.98*						0.80
Grazing pasture	0.35	0.85	0.8						0.67
Sudan grass	*0.5*	*1.03*	*0.98*	28	40	27	17	112	0.70
Turf grass	0.85	0.9	0.9						0.88

[a] $K_{c,ini}$: K_c in the initial and developmental growing stages.
[b] $K_{c,mid}$: K_c in the middle growing stage.
[c] $K_{c,end}$: K_c in the late growing stage.
[d] $K_{c,avg}$: Average seasonal K_c value calculated by weighting K_c in a different growing stage with the duration of that growing stage, or by averaging the K_cs in a different growing stage, when the duration of different growing stages are not available.
[e] Values for deciduous orchard.
[f] Values in Italic font are the average of the reported range. Source: Allen et al. (1998), Tables 11 and 12.

Table C-38 Range of $K_{c,avg}$ for Different Types of Crops under Non-Stressed and Well-Managed Conditions

	Fruits, Nuts, Grains, and Non-Leafy Vegetables	Leafy	Forage	Grain
Minimum	0.41	0.37	0.62	0.57
Max	0.93	0.90	0.88	0.73
Average	0.69	0.67	0.73	0.63

It should be pointed out that the literature values of K_c discussed in the previous paragraphs are valid for the growing season. However, the analysis performed by RESRAD-ONSITE or RESRAD-OFFSITE requires the input of annual average value; therefore, the K_c value during the off-season should also be developed. It is considered that during the off-season, the cold weather restricts the growth of crops and minimizes farming activities; as a result, the agriculture fields are either barren or with little ground coverage. A low-end value of 0.3 was selected among the listed value in Table C-37 for use during the off-season. The K_c values can be used together with ET_o to obtain the annual evapotranspiration rate of a specific crop, ET_c. ET_c then can be plugged into Equation (C-21) as the numerator and be divided by the amount of water delivered to the root zone [$(1 - C_r)\ P_r + IR_r$], to obtain C_e, the evapotranspiration coefficient.

Because C_e is strongly influenced by climatic conditions (i.e., temperature and precipitation) and is highly site-specific, no recommendation is provided for its default distribution. Derivation of site-specific evapotranspiration coefficients are recommended when performing a RESRAD-OFFSITE calculation. The procedure of estimating site-specific distribution ranges for C_e is described in the following paragraphs.

Table C-39 demonstrates the procedure that can be used in estimating site-specific evapotranspiration coefficients for different crop fields. First, the agroclimatic characteristics of the agricultural fields must be determined to select the most representative region from the four choices listed in Table C-36 (humid and sub-humid tropical or subtropical region, arid and semi-arid tropical or subtropical region, humid and sub-humid temperate region, and arid and semi-arid temperate region). Then, the number of days in a year must be distributed to the four temperature ranges: ~0°C, ~10°C, ~20°C, and >30°C. With the daily ET_o (mm/d) listed in Table C-36, the total amount of water lost through evapotranspiration for the reference crop can be calculated for each temperature range in a year. In Table C-39, the fields were assumed to be in a semi-arid temperate region. Note that the daily ET_o corresponding to the temperature range of ~0°C was not provided by FAO [Allen et al. 1998]. A range of 0–1 mm/d was assumed in the example, by inference from the values for other temperature ranges.

The amount of evapotranspiration, ET_os, for the reference crop must be corrected by a crop coefficient, K_c, to determine the amount of evapotranspiration for different crop categories. On the basis of the seasonal average, $K_{c,avg}$, for different crop categories (listed in Table C-38), and a stress correction factor, K_s, the adjusted K_c for actual field conditions can be obtained (as the product of $K_{c,avg}$ and K_s). In Table C-39, a stress correction factor of 1, 1, 0.75, and 0.75 was selected for the four crop fields, respectively, assuming the non-leafy vegetable and leafy vegetable fields receive more irrigation and care than the forage and grain fields. Because cultivation of crops would not be possible throughout the entire year due to low temperatures in the off-season, the adjusted K_c values calculated above were applied only during the growing period. In Table C-39, the growing period was limited to the time when the temperature was in the range of ~10 °C to >30 °C. When the temperature dropped to ~0 °C, crops were considered to wither and growth eventually stopped. An adjusted K_c value of 0.3 was used for the temperature range of ~0 °C to account for the fact that the ground surface would be only partially covered by dead leaves and transpiration would not be active. The ET_o values calculated for different temperature ranges then were multiplied by the corresponding K_c values to obtain the ET_c values for actual crops. Table C-39 lists the low and high bounds of ET_c for different temperature ranges and different crop categories. Finally, the annual evapotranspiration rate, ET_r (m/yr), can be calculated as the sum of ET_c from different temperature ranges.

The last portion of Table C-39 presents estimates of the evapotranspiration coefficient calculated by using Equation (C-21). The site-specific annual precipitation rate should be used in the calculation, and the values for the four different crop fields should be the same if they are located in the same region. The irrigation rate should reflect the stress conditions that crops experience in the fields. In Table C-39, the irrigation rates assumed for non-leafy vegetables, leafy vegetable, forage, and grain fields were 0.5, 0.7, 0.2, and 0.2 m/yr, respectively. The irrigation rates for non-leafy vegetable and leafy vegetable fields were higher than for the forage and grain fields, reflecting the assumed stress correction factor (K_s) of 1 for the two vegetable fields and 0.75 for the two fodder fields. Site-specific runoff coefficients should also be obtained and used. In Table C-39, a value of 0.25 was used for all the fields. The final calculation results for the evapotranspiration coefficient, E_c, showed a range of 0.41-0.78 for the non-leafy vegetable field, 0.34-0.65 for the leafy-vegetable field, 0.43-0.82 for the forage field, and 0.37-0.71 for the grain field. A uniform distribution with the calculated low and high bounds can then be assumed and used as site-specific input to run the RESRAD-OFFSITE code.

For comparison, Palmer (1993) gives a range of 0.6 to 0.75 for irrigation efficiency, which is the percentage of irrigation water that is delivered to the root zone and is available for evapotranspiration. A very small fraction of water is actually used for plant growth; the majority would be lost through evapotranspiration. The efficiency is influenced by the size of the irrigated area because of the effect of conveyance losses between the points of delivery to the crop fields. The Water Atlas of the United States (Geraghty et al. 1973) states that 70 percent of the water that falls as precipitation on the conterminous United States is lost by evapotranspiration from non-irrigated lands.

Table C-39 Example Calculations for the Evapotranspiration Coefficients for a Site Located in a Temperate Semi-Arid Region

Temperatures	Days per Year[a]	Range of ET_o (mm/d)[b]		Total ET_o (mm)[c]	
		Low	High	Low	High
Mean temperature ~ 0 °C	120	0	1	0	120
Mean temperature ~ 10 °C	120	1	3	120	360
Mean temperature ~ 20 °C	65	4	7	260	455
Mean temperature about > 30 °C	60	6	9	360	540

Crop Category	$K_{c,avg}$[d]	K_s[e]	Adjusted K_c[f]	K_c at Different Temperature[g]			
				~ 0°C	~ 10°C	~ 20°C	> 30°C
Non-Leafy vegetable	0.69	1	0.69	0.30	0.69	0.69	0.69
Leafy vegetable	0.67	1	0.67	0.30	0.67	0.67	0.67
Forage	0.73	0.75	0.55	0.30	0.55	0.55	0.55
Grain	0.63	0.75	0.47	0.30	0.47	0.47	0.47

Crop Category	Total ET_c (mm) for Different Temperature[h]								Annual Evapotranspiration Rate, ET_r (m/yr)[i]	
	~ 0°C		~ 10°C		~ 20°C		> 30°C			
	Low	High	Low	High	Low	High	Low	High	Low	High
Non-Leafy vegetable	0	36	83	248	179	314	248	373	0.51	0.97
Leafy vegetable	0	36	80	241	174	305	241	362	0.50	0.94
Forage	0	36	66	197	142	249	197	296	0.41	0.78
Grain	0	36	57	170	123	215	170	255	0.35	0.68

Crop Category	Annual Precipitation (m/yr)[j]	Annual Irrigation (m/yr)[k]	Runoff Coefficient[l]	Evapotranspiration Coefficient[m]	
				Low	High
Non-Leafy vegetable	1	0.5	0.25	0.41	0.78
Leafy vegetable	1	0.7	0.25	0.34	0.65
Forage	1	0.2	0.25	0.43	0.82
Grain	1	0.2	0.25	0.37	0.71

[a] Values are the number of days of the specified temperature during a year.

[b] Range of ET_o was taken from Table C.4.3-2 except for temperature ~ 0 °C, for which 0 and 1 mm/d were assumed to be the bounding values.

[c] Total ET_o was obtained by multiplying the daily ET_o with the number of days of the specific temperature range.

[d] $K_{c,avg}$ is the seasonal average of K_c under standard, non-stressed conditions. The value was taken from Table C.4.3-4.

[e] K_s is the correction factor to $K_{c,avg}$ for considering the deviation from the standard, non-stressed growing conditions.

[f] Adjusted K_c is the multiplication product of $K_{c,avg}$ and K_s, and is the crop correction factor during the growing period.

[g] K_c at different temperature was set to the adjusted K_c value when growth of crop was considered feasible under the specific temperature. Otherwise, it was set to a value of 0.3, a value assumed to reflect the condition when growth of crop is not possible, irrigation is discontinued, and the ground surface is covered with dead leaves or weeds. It was assumed that when the temperature drops to around 0 °C or lower, growth of crop is not possible.

[h] Total ET_c for different temperature condition is the product of K_c at different temperature and the low or high end of Total ET_o (mm).

[i] ET_r is the sum of the "Total ET_c for different temperature," expressed in terms of m/yr.

[j] Annual precipitation rate was set to the same value for different crop fields, assuming the crop fields are located in the same region. Site-specific value should be used.

[k] Annual irrigation rate may be different for different crop fields. The value is related to the K_s value used to consider deviation of the actual conditions from the standard, non-stressed conditions. Sufficient irrigation would provide enough water for plant growth, thereby reducing the deviation from standard conditions.

[l] The runoff coefficient can assume different values for different crop fields. In the example, the same value was used for all crop fields.

[m] The evapotranspiration coefficient was calculated by using equation C.4.3-1. The value of the coefficient ranges from 0 to 1. Therefore, if the calculated value exceeds 1, it should be replaced with 1.

C.4.4 Humidity

Applicable Code: RESRAD-ONSITE, RESRAD-OFFSITE and RESRAD-BUILD

Description: In RESRAD-ONSITE and RESRAD-OFFSITE, this parameter represents the average absolute humidity outdoors. The absolute humidity is an input used only for the computation of tritium concentration in air if tritium is present in the soil. In RESRAD-BUILD, this parameter represents the average absolute humidity in the building. The absolute humidity is an input used only for the tritium volume source model.

Units: grams per cubic meter (g/m^3)

Probabilistic Input:

RESRAD-ONSITE and RESRAD-OFFSITE

Distribution: truncated lognormal-n

Defining Values for Distribution:

Underlying mean value: 1.98	Lower quantile value: 0.001
Underlying standard deviation: 0.334	Upper quantile value: 0.999

RESRAD-BUILD

Distribution: uniform

Defining values for distribution:

Minimum: 6.5 Maximum: 13.1

Discussion: RESRAD-ONSITE, RESRAD-OFFSITE, and RESRAD-BUILD require input for the absolute humidity, the actual concentration of water vapor in air. The relevant data available are given in terms of the relative humidity. The relative humidity of a water vapor-air mixture is defined as 100 times the partial pressure of water divided by the saturation vapor pressure of water at the same temperature. For this section, relative humidity was converted to absolute humidity by assuming a total pressure of 1 atmosphere in conjunction with a given temperature and partial pressure of water at that temperature. Tabulated values for the partial pressure of water over a range of temperatures were obtained from Dean (1999).

For RESRAD-BUILD, the average humidity in a building depends on the functioning of heating, ventilation, and air conditioning (HVAC) systems of the building. At normal room temperatures, the relative humidity (RH) in occupied buildings should be maintained between approximately 30 and 60 percent to help maintain human health and comfort (Sterling et al., 1985). With respect to health, this range in RH minimizes allergic reactions and bacterial and viral growth. Human discomfort is noted at low and high humidity. Discomfort at low RH results from the drying of skin, hair, and respiratory membranes.

Because HVAC systems are designed to maintain a healthy environment for building occupants (the 30 to 60 percent RH range), a uniform distribution for the corresponding absolute humidity range is used in RESRAD-BUILD. The range of 30 to 60 percent relative humidity corresponds to an absolute humidity range of 6.5 to 13.1 g of water per cubic meter at 1 atmosphere pressure and 24°C (75°F). The probability density function is shown in Figure C-24. However, RH values lower than 30 percent may occur in buildings that do not have a humidification system, especially during the winter in colder climates. Also, RH values higher than 60 percent may occur in buildings using natural ventilation in more temperate climates. In more temperate climates where natural ventilation may be employed, the humidity inside the building will be more representative of the outside levels.

For RESRAD-ONSITE and RESRAD-OFFSITE, data from 231 weather stations across the conterminous 48 U.S. states, most with data for more than 30 years of record, were analyzed to obtain a perspective on ambient outdoor humidity levels. Annual average morning and afternoon RH levels were used in conjunction with annual average temperature readings at these weather stations (National Climatic Data Center [NCDC] 1999) to estimate absolute humidity levels. The morning and afternoon RH levels were averaged for each station to obtain one value for the annual average relative humidity for use in estimating the absolute humidity.

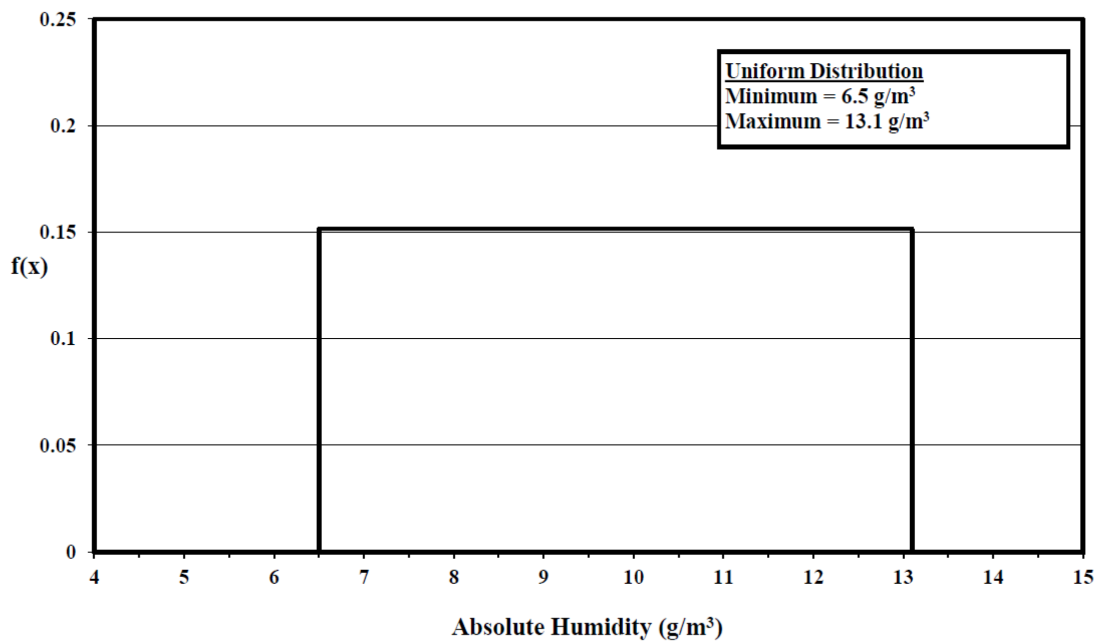

Figure C-24 Absolute Humidity Probability Density Function for RESRAD-BUILD

The resulting absolute humidity probability density function was fit reasonably well to a lognormal distribution by using Bayesian estimation, as shown in Figure C-25. This distribution is only indicative of what might be expected, because the sampling is not representative of a uniform grid across the United States, although it is indicative of the larger population centers. Site-specific data should be used when available.

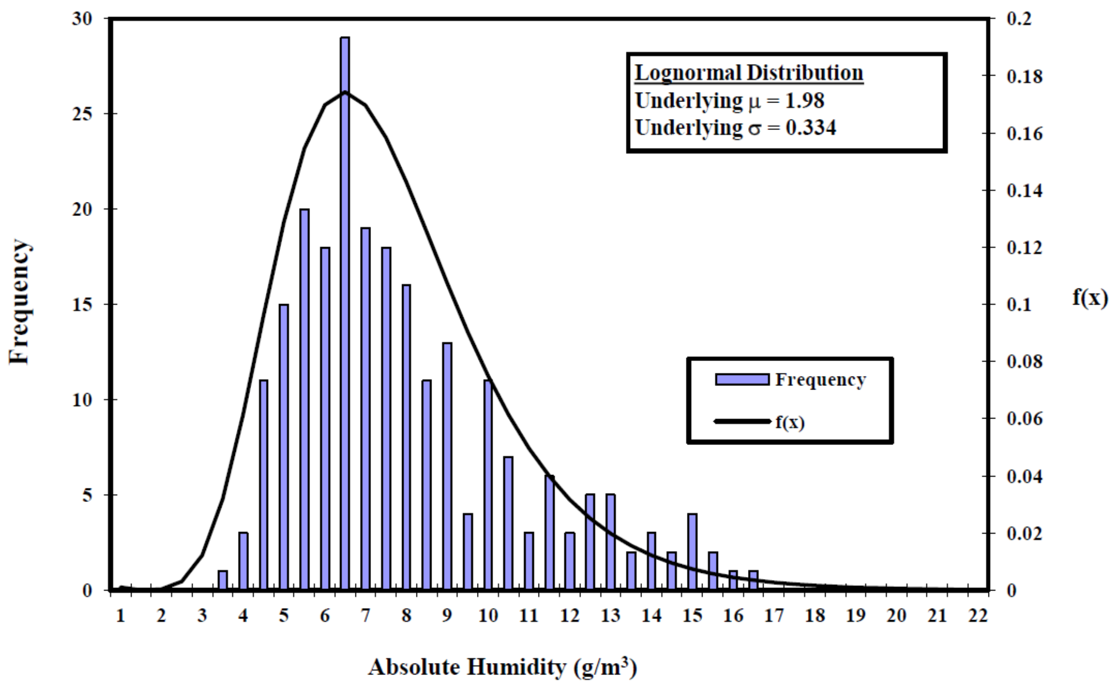

Figure C-25 Absolute Humidity Probability Density Function for RESRAD-ONSITE and RESRAD-OFFSITE

C.4.5 Wind Speed

Applicable Code: RESRAD-ONSITE and RESRAD-OFFSITE

Description: The wind speed represents the annual average wind speed at a site for RESRAD-ONSITE. For RESRAD-OFFSITE, the wind speed is divided into six intervals for use in a joint-frequency distribution with the atmospheric stability class when estimating air dispersion of contaminants. Each wind speed interval is characterized by a representative wind speed.

Units: meters per second (m/s)

Probabilistic Input:

RESRAD-ONSITE

Distribution: bounded lognormal-n

Defining Values for Distribution:

Underlying mean value: 1.445 Lower limit: 1.4

Underlying standard deviation: 0.2419 Upper limit: 13

RESRAD-OFFSITE

Distribution: uniform

Defining Values for Distribution: See Table C-40 for the input values.

Discussion: The wind speed at a given location varies by time of day and by season. Wind speed distribution at a given site has been characterized by both lognormal (Luna and Church, 1974; Justus et al., 1976) and Weibull distributions (Justus et al., 1976). Annual average wind speed varies by location across the United States. For RESRAD-ONSITE, annual average wind speed data from 271 United States weather stations (NCDC, 1999) were analyzed to obtain a reasonable estimate for a nationwide distribution for the United States. The average number of years of recorded data available for each station was 43 years.

The nationwide distribution was shown to be fit well by a lognormal distribution. Bayesian estimation was used to fit the probability density function shown in Figure C-26 to a lognormal distribution. The maximum likelihood mean and standard deviation for the wind speed distribution were estimated to be 1.445 and 0.2419, respectively. Thus, the median (50th percentile) of the distribution corresponds to 4.2 m/s ($e^{1.445}$), near the national average wind speed of 4.1 m/s as determined by taking the arithmetic average of the 271 station annual averages. Lower and upper limits of 1.4 and 13 m/s imposed on the distribution correspond to the 0.000001 and 0.999999 quantiles, respectively.

Table C-40 Uniform Distribution Limits for the Wind Speed Intervals in RESRAD-OFFSITE

Wind Speed Interval	Minimum (m/s)	Maximum (m/s)
1	0.514	1.80
2	1.81	3.34
3	3.35	5.40
4	5.41	8.49
5	8.50	11.1
6	11.2	14.1

This distribution is only indicative of what might be expected, because the sampling is of only limited size (271 data points) and is not representative of a uniform grid across the United States. Also, monitor sites are not always representative of all nearby areas because of differences in terrain over relatively short distances.

For RESRAD-OFFSITE, a joint frequency distribution of wind speed and atmospheric stability is used for each direction of a wind rose when estimating downwind contaminant concentrations. The frequency relates to the fraction of time that the atmospheric conditions in the specified sector (compass direction) fall within each wind speed interval and stability class combination. In keeping with the format of STAR joint frequency distribution data files, the code uses 6 wind speed intervals and 6 atmospheric stability classes for each of 16 sectors. In a STAR file, the wind speed intervals are defined as shown in Table C-41. Each wind speed interval in RESRAD-OFFSITE is represented by an average value for use in the atmospheric dispersion calculations. For a probabilistic treatment, the wind speed can be assumed to have a uniform distribution across each interval, bounded by the limits for each interval for which the data is valid. The limits are shown in Table C-40.

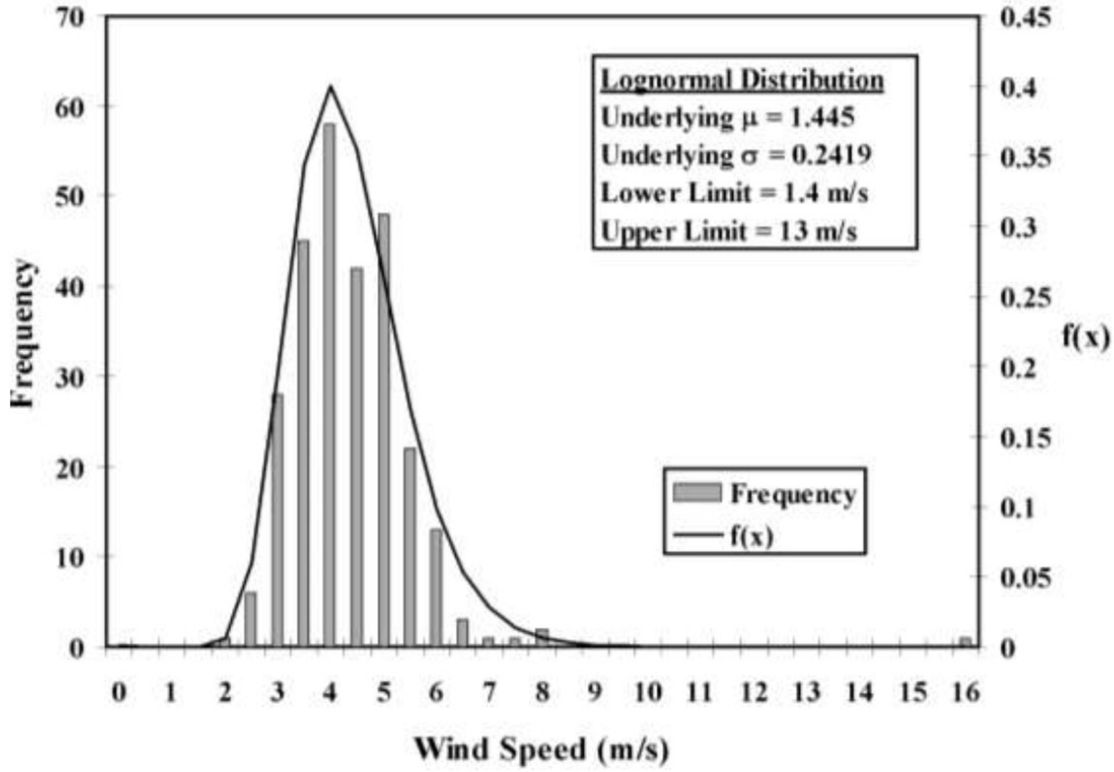

Figure C-26 Wind Speed Histogram and the Fitted Probability Density Function for RESRAD-ONSITE

Table C-41 STAR Wind Speed Intervals

Wind Speed Interval	Lower Bound[a] (knots [m/s])	Upper Bound[a] (knots [m/s])	RESRAD-OFFSITE (m/s)
1	1 (0.514)	3 (1.54)	0.89
2	4 (2.06)	6 (3.09)	2.46
3	7 (3.6)	10 (5.14)	4.47
4	11 (5.66)	16 (8.23)	6.93
5	17 (8.75)	21 (10.80)	9.61
6	>21 (10.80)		12.52

[a] Source: Parks (1992).

C.4.6 Mass Loading for Inhalation and Foliar Deposition

Applicable Code: RESRAD-ONSITE and RESRAD-OFFSITE

Description: The mass loading for inhalation is the mass loading of particulates which is respirable (RESRAD-ONSITE). The mass loading for foliar deposition represents the concentration of contaminated airborne particulate matter (e.g., soil; RESRAD-ONSITE and RESRAD-OFFSITE).

Units: grams per cubic meter (g/m^3)

Probabilistic Input:

Mass Loading for Inhalation (RESRAD-ONSITE)

Distribution: continuous linear

Defining Values for Distribution: See Table C-42 for the input values.

Mass Loading for Foliar Deposition (RESRAD-ONSITE and RESRAD-OFFSITE)

Distribution: truncated lognormal-n

Defining Values for Distribution:

Underlying mean value: -10.02	Lower quantile value: 0.001
Underlying standard deviation: 0.455	Upper quantile value: 0.999

Discussion: Resuspended contaminated soil and dust pose a radiological inhalation risk. The mass loading for inhalation input to RESRAD-ONSITE provides the time-averaged concentration of contaminated soil and dust. The PM-2.5 particles represent the fine particle fraction that poses the highest respiratory hazard (EPA, 2004). Ambient PM-2.5 air concentrations were obtained from the EPA's AirData Web site (EPA, 2005). The PM-2.5 particulate concentration data was used in developing distribution for mass loading for RESRAD-ONSITE.

Resuspended soil and dust from the primary contaminated area can be dispersed downwind to contaminate other areas. The mass loading for RESRAD-OFFSITE provides the concentration of contaminated airborne material used to calculate the contaminant release rate to the atmosphere. The amount of this material is represented by the amount of total suspended particulates (TSP). The TSP concentrations were also obtained from the EPA's AirData Web site (EPA, 2005). The TSP concentration data was used in developing mass loading distribution for RESRAD-OFFSITE. The respirable portion of resuspended material can be represented by the PM-2.5 fraction of airborne particulate matter (particulates < 2.5 µm in diameter). The respirable fraction along with TSP mass loading is used in RESRAD-OFFSITE code to calculate radiological inhalation risk. The concentration of contaminated airborne material is also used to calculate the foliar deposition in both RESRAD-ONSITE and RESRAD-OFFSITE codes.

Five years (2000-2004) of annual average ambient PM-2.5 and TSP air concentration measurements from approximately 1,690 (PM-2.5) or 345 (TSP) air monitoring stations across the United States and its territories were analyzed. The data are only indicative of what might be expected because the set of monitoring stations included is not representative of a uniform grid across the United States. Furthermore, the monitor sites are not always representative of all nearby areas because of differences in local weather patterns. Thus, site-specific data should be used when available.

Table C-42 Cumulative Distribution Function for Mass Loading for Inhalation (RESRAD-ONSITE)

Mass Loading ($\mu g/m^3$)	Cumulative Probability	Mass Loading ($\mu g/m^3$)	Cumulative Probability	Mass Loading ($\mu g/m^3$)	Cumulative Probability
0	0.0000	8	0.9514	36	0.9989
1	0.0001	19	0.9664	37	0.9989
2	0.0005	20	0.9743	38	0.9990
3	0.0024	21	0.9801	>38	1.0000
4	0.0092	22	0.9842		
5	0.0237	23	0.9876		
6	0.0493	24	0.9899		
7	0.0870	25	0.9924		
8	0.1343	26	0.9940		
9	0.1946	27	0.9950		
10	0.2725	28	0.9959		
11	0.3666	29	0.9965		
12	0.4720	30	0.9967		
13	0.5815	31	0.9974		
14	0.6895	32	0.9980		
15	0.7929	33	0.9983		
16	0.8750	34	0.9985		
17	0.9223	35	0.9986		

Source: EPA's AirData Web site.

Figure C-27 presents a histogram of the data in conjunction with the cumulative distribution function (CDF) for the PM-2.5 data for inhalation. Table C-42 lists the values used for the CDF. For the mean mass loading, the TSP probability density function was fit reasonably well to a lognormal distribution by using nonlinear least squares regression analysis, as shown in Figure C-28.

RESRAD-ONSITE code uses the mass loading factor to estimate the annual inhalation dose. Therefore, use of a high, short-term loading will result in an overestimate of the annual dose. A time average mass loading factor should be used in RESRAD-ONSITE and RESRAD-OFFSITE for a more realistic dose estimate. Similarly, the use of short-term loadings for the mass loading in RESRAD-OFFSITE is also discouraged

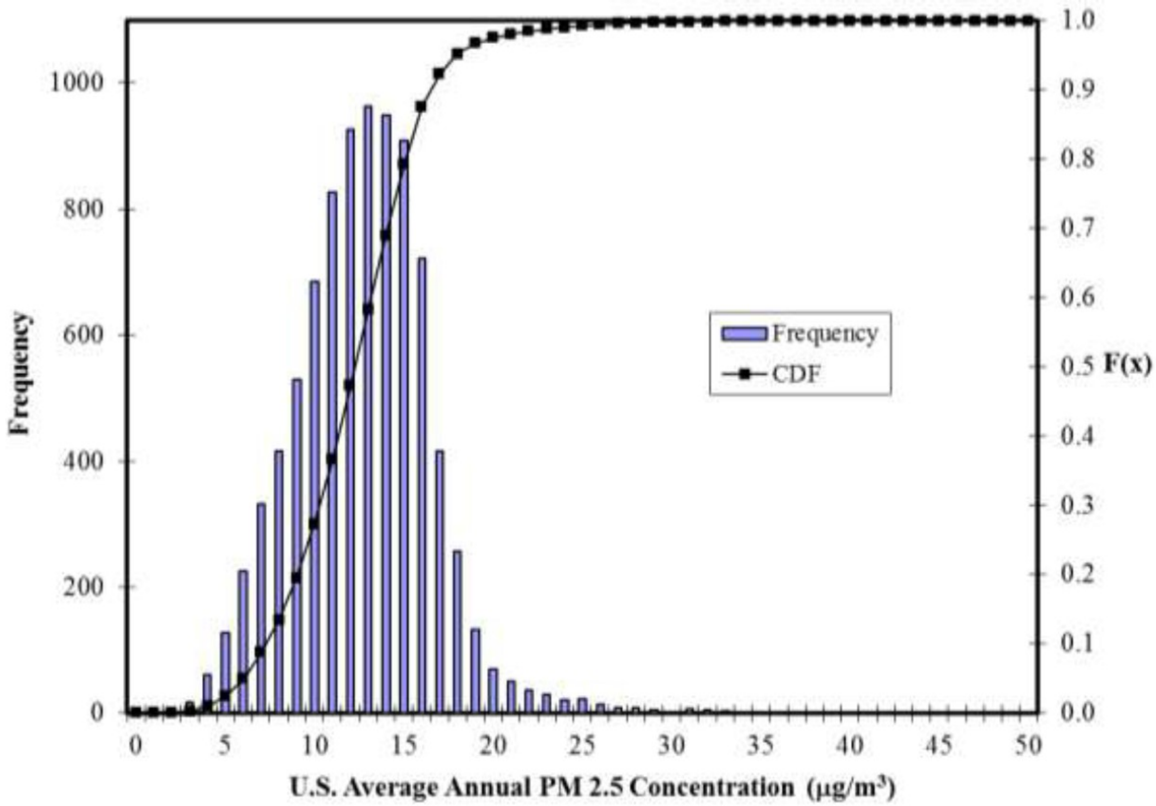

Figure C-27 Mass Loading for Inhalation Histogram and Cumulative Distribution Function for RESRAD-ONSITE

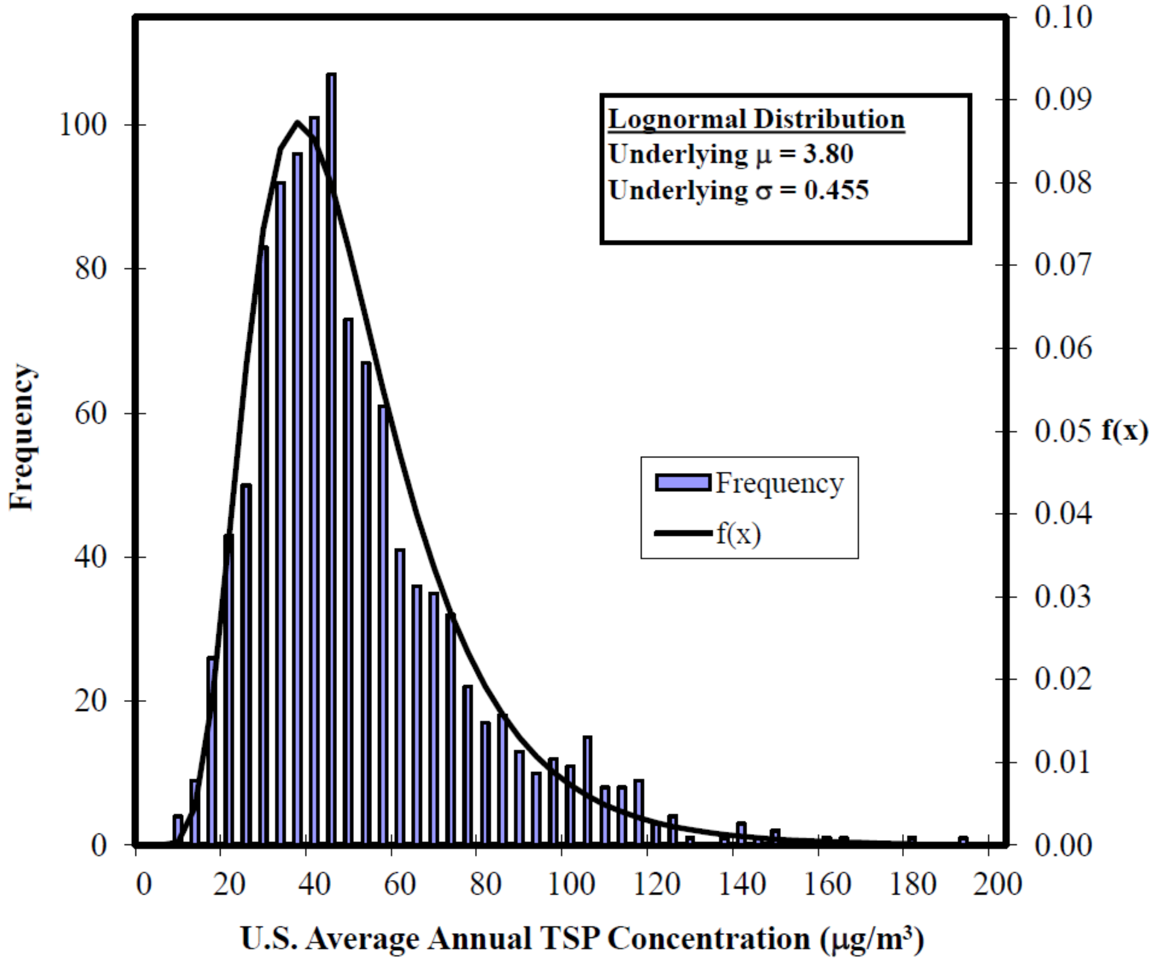

Figure C-28 Mass Loading for Inhalation Histogram and Probability Density Function for RESRAD-OFFSITE

C.4.7 Deposition Velocity

Applicable Code: RESRAD-BUILD and RESRAD-OFFSITE

Description: In RESRAD-BUILD, this parameter represents the indoor deposition velocity of contaminant particles in the building air. In RESRAD-OFFSITE, this parameter represents the outdoor deposition velocity of airborne contaminant particles blown downwind from the contaminated area.

Units: meters per second (m/s)

Probabilistic Input:

RESRAD-BUILD

Distribution: loguniform

Minimum: 2.7E-06 Maximum: 2.7E-03

RESRAD-OFFSITE

Distribution: loguniform

Minimum: 1.0E-06 Maximum: 1.0

Discussion: The deposition velocity characterizes the rate at which particles in air deposit on a surface. In RESRAD-OFFSITE, the outdoor deposition velocity is used to calculate the rate at which radionuclides are deposited at the offsite location by multiplying the downwind air concentration by the deposition velocity at each location of interest. The deposition velocity, v_d, in outdoor air has traditionally been expressed as (Sehmel, 1980):

$$v_d = \frac{-F}{\chi} \tag{C-22}$$

F is the deposition flux, and χ is the airborne concentration. Thus, experimental determination of the deposition velocity involves the measurement of both the aboveground air concentration and the depositing flux. The air concentration at approximately 1 m from the ground surface has been historically used for this calculation.

The outdoor deposition velocity is a function of particle, meteorology, and ground surface properties (Sehmel, 1980). Important particle properties include diameter, density, and shape; important meteorological properties include atmospheric stability and wind speed; and important surface properties include surface roughness and composition.

The decay rate, λ_d, of particles in indoor air due to deposition is often expressed as:

$$\lambda_d = \frac{v_d A_d}{V} \tag{C-23}$$

Where:

A_d =the surface area available for deposition, and
V =the volume of air.

For indoor deposition, the deposition velocity depends on particle and room properties. Important particle properties include diameter, density, and shape, as is the case for outdoor deposition. Room properties include air viscosity and density, turbulence, thermal gradients, and surface geometry.

Nazaroff and Cass (1989) have developed a relationship for the indoor deposition velocity of particulates as a function of particle size. Such theoretical calculations are not likely to produce satisfactory results because of lack of knowledge about near-surface flow conditions (Nazaroff et al., 1993), but they can provide insight into the general trend of deposition velocity as a function of particle size.

Figure C-29 presents an idealized representation of deposition velocity on a floor as a function of particle size on the basis of the methodology in Nazaroff and Cass (1989). A similar trend is observed and predicted for deposition of particles outdoors (Sehmel, 1980).

Because deposition velocities depend on particle size, it is expected that the probability density function distribution of deposition velocities is dependent on the particle size distribution. The particle size distribution in the atmosphere typically exhibits three modes (Seinfeld and Pandis, 1998). Fine particles (particles less than 2.5 μm in diameter) can be divided into two modes, the nuclei mode and the accumulation mode. The nuclei mode (particles approximately 0.005–0.1 μm in diameter) contains the largest number of particles in the atmosphere but represents only a few percent of the total mass of airborne particles (Seinfeld and Pandis, 1998). Nuclei mode particles are formed from condensation of atmospheric gases, such as combustion products. Depletion of nuclei mode particles occurs primarily through coagulation with larger particles. The accumulation mode (particles approximately 0.1–2.5 μm in diameter) accounts for a large portion of the aerosol mass. Accumulation mode particles are formed through coagulation of particles in the nuclei mode and through condensation of gases onto smaller particles. Because removal mechanisms are not as efficient for this size range, particles tend to accumulate (hence the term “accumulation mode”). Coarse particles (diameters greater than 2.5 μm) constitute the third mode. Coarse mode particles are formed primarily from mechanical processes. Other sources of coarse particles include windblown dust and plant particles.

Each of the three particle size modes can be well characterized by lognormal distributions (John, 1993). By using the means and standard deviations from Whitby and Sverdrup (1980), Figure C-30 demonstrates the trimodal nature of the particle size distributions commonly found. Similar distributions are expected for indoor air concentrations, with the exception of some indoor source contributions, because the building shell has been shown to be an insignificant barrier to particle sizes under 10 μm (Yu et al., 2000).

A broad probability density function distribution is expected for the deposition velocity indoors and outdoors when comparing the trend in deposition velocity with the distribution of particles by size (Figure C-29 and Figure C-30, respectively) and taking into consideration the variability of each. Indoor experimental estimates provide support for such an assumption, as shown in Table C-43 through Table C-45. Also, because deposition is dependent on local airflow patterns (Nazaroff and Cass, 1989), in conjunction with particle size and mass, a small difference in the local air handling system (such as changes due to climate or season) can easily cause a shift in deposition velocity. Because the deposition velocity input in RESRAD-BUILD is used for all particle sizes and species under a potential range of airflow conditions, a loguniform distribution is assigned, with minimum and maximum values of 2.7E-06 m/s and 2.7E-03 m/s, respectively, as found in Table C-43 through Table C-45. This distribution is shown in Figure C-31.

In addition to particle size, the deposition velocity of particulates outdoors is strongly influenced by wind speed, weather stability category, and surface roughness, among other effects (Sehmel, 1980,1984; Harper et al., 1995). Thus, the suggested parameter distribution for the outdoor deposition velocity is necessarily broad because the air dispersion model in RESRAD-OFFSITE does not explicitly account for particle size and surface roughness. An expert panel on deposition velocity was convened to provide suggested values for the range of outdoor deposition velocity under a variety of conditions for different particle sizes (Harper et al., 1995). For wind speeds of 2 and 5 m/s, estimated values for particle sizes 0.1, 0.3, 1.00, 3.00, and 10.00 μm were given for the 0, 5, 50, 95, and 100 quantiles for deposition on an urban area, meadow, forest, and human skin. The expert estimates generally varied by an order of magnitude or more on the low and high end of the deposition velocity range for most cases. Based primarily on the values for both wind speeds, particle sizes of 0.1 and 10 μm, and deposition on meadow and urban areas, a loguniform distribution with a minimum value of 1.0E-06 m/s and a maximum value of 1.0 m/s were selected for RESRAD-OFFSITE. The corresponding probability distribution is shown in Figure C-32.

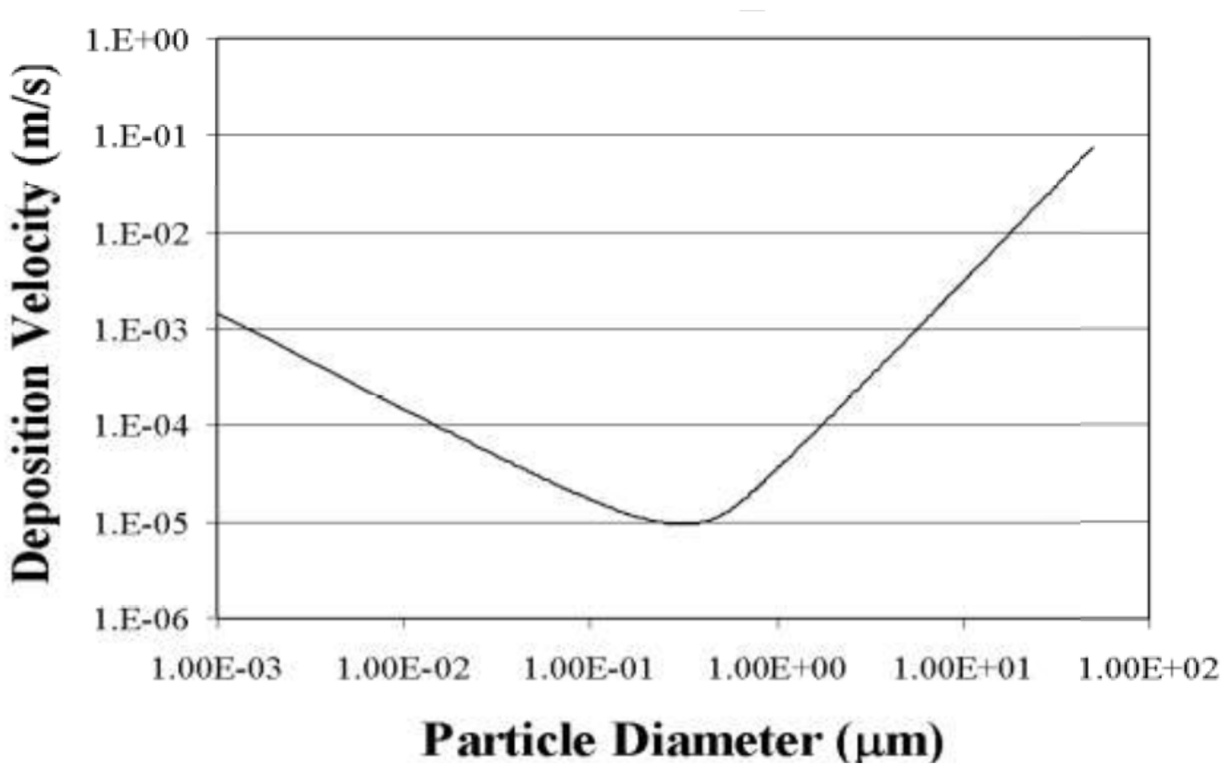

Figure C-29 Estimated Indoor Deposition Velocities by Particle Size

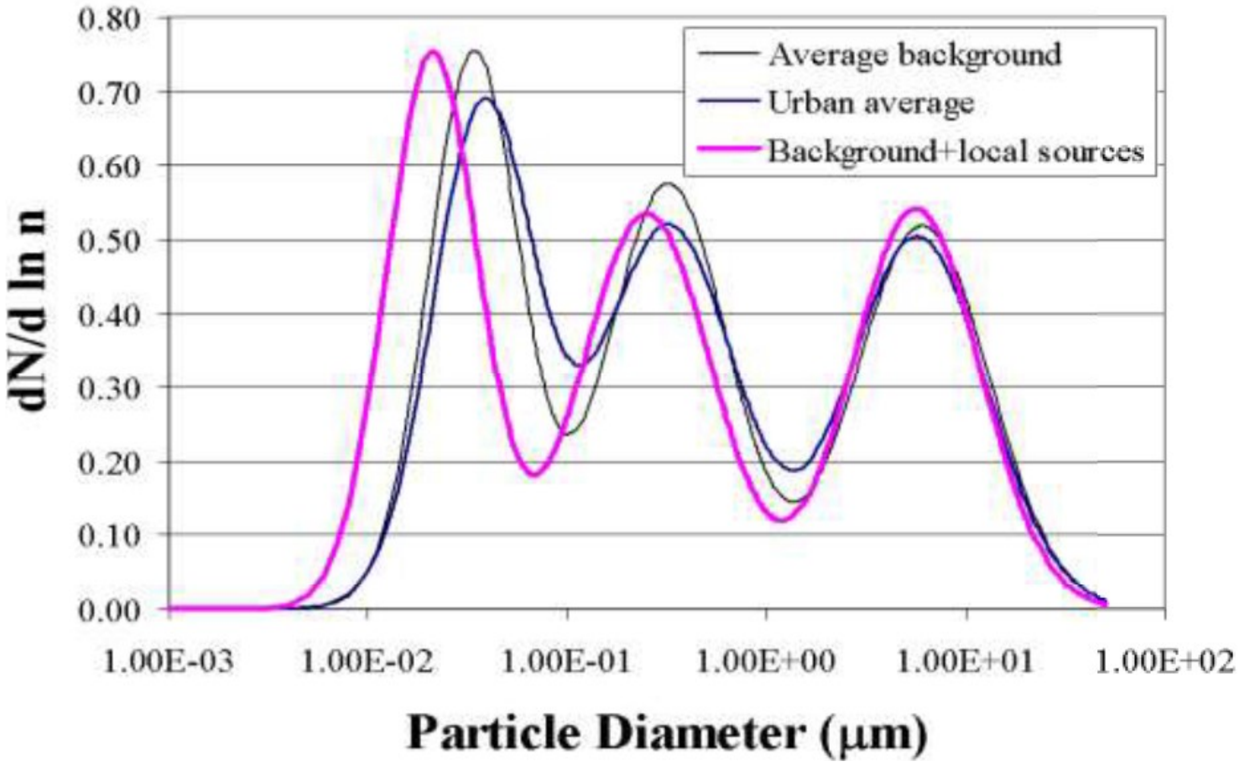

Figure C-30 Trimodal Nature of Aerosol Particle Size Distribution

Table C-43 Estimated Indoor Deposition Velocities by Particle Size

Particle Size (μm)	Deposition Velocity (m/s)	Comments	Reference
0.71	1.7E-05	Be-7 with natural air exchange	Lang, 1995
1.4	1.3E-05		
2.8	6.7E-05		
0.71	1.33E-04	Be-7 with forced air exchange	
1.4	2.66E-04		
2.8	3.88E-04		
1-2	1.7E-04	Data Set 1 (different sample dates using SF_6 tracer)	Thatcher and Layton, 1995
2-3	3.7E-04		
3-4	5.1E-04		
4-6	1.1E-04		
1-2	1.9E-04	Data Set 2	
2-3	5.0E-04		
3-4	5.6E-04		
4-6	1.2E-04		
1-5	3.1E-04	Data Set 3	
5-10	9.1E-04		
10-25	1.6E-04		
>25	2.7E-03		
0.07	1.72E-05	Estimates based on data in Offermann et al. (1985) for cigarette combustion	Nazaroff and Cass, 1989
0.10	2.7E-06		
0.12	3.8E-06		
0.17	3.8E-06		
0.22	4.7E-06		
0.26	8.9E-06		
0.35	8.2E-06		
0.44	8.7E-06		
0.56	9.8E-06		
0.72	1.51E-05		
0.91	1.3E-04		
<2.5	3.0E-05 and 3.0E-05	Sulfate ion particulates at two locations	Sinclair et al., 1985
2.5-15	1.0E-02 and 2.0E-03	Calcium ion particulates at two locations	

Table C-44 Estimated Deposition Velocities by Particle Size in Residences with and without Furniture

Particle Size (µm)	Average Deposition Velocity (m/s)	
	Without Furniture	With Furniture
0.5	6.1E-05	8.2E-05
2.5	1.33E-04	1.73E-04
3.0	1.37E-04	2.25E-04
4.5	2.88E-04	2.88E-04
5.5	3.04E-04	3.24E-04

Table C-45 Estimated Indoor Deposition Velocities for Various Radionuclides

Isotope	Mean Deposition Velocity (m/s)
Cs-137	6.4E-05
Cs-134	6.2E-06
I-131 (particulate)	1.1E-04
Be-7	7.1E-05
Ru-103	2.0E-04
Ru-106	1.7E-04
Ce-141	3.1E-04
Ce-144	3.9E-04
Zr-95	5.8E-04
Nb-95	1.9E-04

Source: Roed and Cannell (1987).

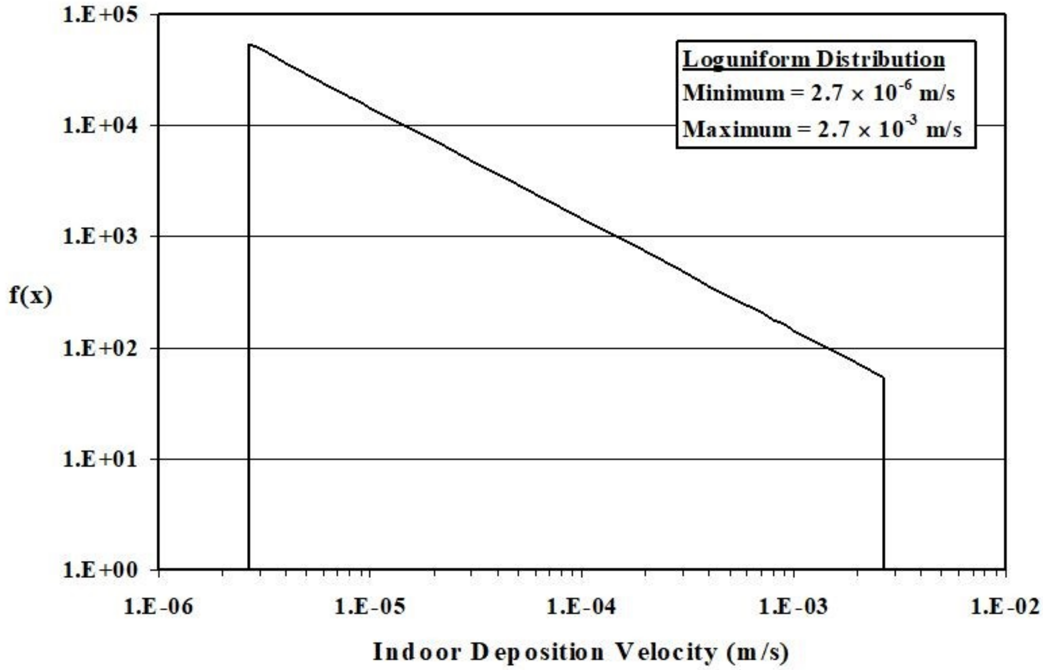

Figure C-31 Indoor Deposition Velocity Distribution for RESRAD-BUILD

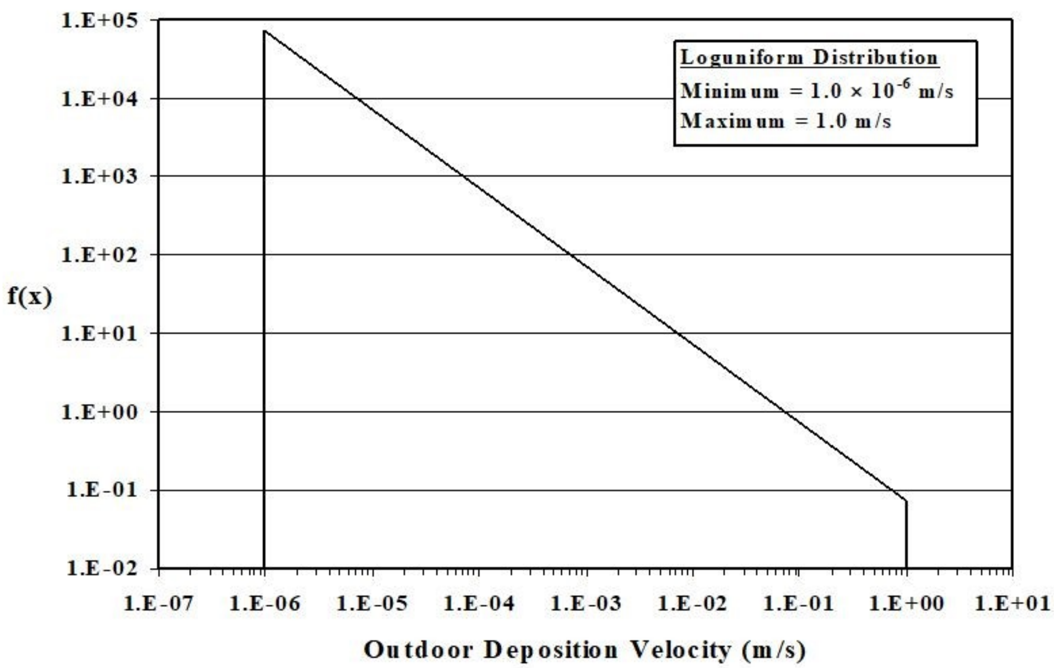

Figure C-32 Outdoor Deposition Velocity Distribution for RESRAD-OFFSITE

C.5 Receptor Characteristics

C.5.1 Inhalation Rate

Applicable Code: RESRAD-ONSITE, RESRAD-OFFSITE and RESRAD-BUILD

Description: This parameter reflects the rate at which a human receptor inhales air contaminated with resuspended airborne material in the building. The absolute humidity is an input used only for the tritium volume source model.

Units: cubic meters per year (m^3/yr) [RESRAD-ONSITE, RESRAD-OFFSITE]
cubic meters per day (m^3/d) [RESRAD-BUILD]

Probabilistic Input:

RESRAD-ONSITE and RESRAD-OFFSITE

Distribution: triangular

Defining Values for Distribution:

RESRAD-ONSITE, RESRAD-OFFSITE

Minimum: 4,380 Maximum: 13,000 Most likely: 8,400

RESRAD-BUILD

Minimum: 12 Maximum: 46 Most likely: 33.6

Discussion: The distribution of inhalation rate varies widely because of differences in time-use activity patterns that are developed for outdoor/indoor and occupational/residential exposures. Because activity levels of various individuals and groups can vary to such a significant extent, it is preferable to derive a range of inhalation rates by using activity data specific for the population under study. In the RESRAD-ONSITE and RESRAD-OFFSITE codes, the yearly inhalation rate is used, which represents the average values for different activity levels both indoors and outdoors for the scenario analyzed. The hourly average inhalation rate in RESRAD-BUILD is meant to represent workers in an occupational setting. For assessments involving other specific activities, inhalation rates can be selected that are thought to be representative of these particular activities. Similarly, if receptors of a certain age group are being evaluated, breathing rate values should be selected specifically for that age group.

The range of estimates of inhalation rate (Table C-46) reflects the differences in patterns of time and activity levels, as well as age, sex, and weight of the individual. Until recently, inhalation rates for the “reference man and woman,” as described by the International Commission on Radiological Protection (ICRP, 1975), were often used as default values. The ICRP best estimates, which are based on 16 hours of light activity and 8 hours of rest, are as follows: 23 m^3/d (range of 23-31 m^3/d) for adult males; 21 m^3/d (range of 18-21 m^3/d) for adult females; and 15 m^3/d for a 10-year-old child. By using different patterns for the time and activity levels, the EPA has proposed a wider range of adult inhalation rates but recommends essentially the same point estimates as the ICRP for “average” adults (EPA, 1985, 1989a, 1991, 1997).

Table C-46 Inhalation Rate Distributions

Basis	Distribution Type	Inhalation Rate (m^3/d) Minimum	Maximum	Mean	Most Likely	References
Based on time-weighted average food-energy intakes adjusted for reporting bias	Triangular					Layton, 1993
Males (lifetime average)		13	17		14	
Females (lifetime average)		9.6	13		10	
Based on average age-adjusted daily energy expenditure rates	Triangular					Layton, 1993
Males (18–60+ yr.)		13	17		15	
Females (18–60+ yr.)		9.9	11		11	
Based on age-adjusted activity patterns and metabolic rates for an "average" day	Triangular					Layton, 1993
Males (20–74 yr.)		13	17		16	
Females (20–74 yr.)		11	15		13	
"Reference man"—Based on light activity (16 hours) and resting (8 hours)	Triangular					ICRP, 1975
Adult male		23	31		23	
Adult female		18	21		21	
Child		-	-		15	
Based on "typical" outdoor activity levels[a]	Triangular					EPA,1985, 1989a, 1991
Adult female		17	70	25	20	
Adult male		13	79	40	20	
Average adult		-	-	34	20	
Based on "typical" indoor activity levels[b]	Triangular					EPA, 1985, 1989a, 1991
Adult female		7	34	11	15	
Adult male		4	38	21	15	
Average adult		-	-	15	15	
Study of age-dependent breathing rates at realistic activity levels	-					Roy and Courtay, 1991
0–0.5 yr.					1.62	
0.5–2 yr.					5.14	
2–7 yr.					8.71	
7–12 yr.					15.3	
12–17 yr.					17.7	

[a] Resting: 28 percent, light activity: 28 percent, moderate activity: 37 percent, heavy activity: 7 percent.
[b] Resting: 48 percent, light activity: 48 percent, moderate activity: 3 percent, heavy activity: 1 percent.

Layton (1993) proposed three alternative approaches for deriving inhalation rates that are based on oxygen uptake associated with energy expenditures: (1) average daily intakes of food energy from dietary surveys, (2) average daily energy expenditure calculated from ratios of total daily expenditure to basal metabolism, and (3) daily energy expenditures determined from a time-activity survey. These approaches consistently yield inhalation rate estimates that are lower than EPA's best "reasonable worst case" estimates and ICRP (1975) reference values. Layton's inhalation rate estimates fall in the recommended range and may be more accurate values for point estimates. However, the approach needs to be further reviewed and validated in the open literature before these lower, less conservative inhalation rate estimates are used.

In EPA (1997), inhalation rates are reported for adults and children (including infants) performing various activities and for outdoor workers and athletes in EPA (1997). The activity levels have been categorized as resting, sedentary, light, moderate, and heavy. Table C-47 summarizes inhalation rate values recommended by the EPA both for long-term and short-term exposure. The daily average inhalation rates for long-term exposure for adults are 11.3 m^3/d for women and 15.2 m^3/d for men.

EPA has used some recent key studies (EPA 2009; Brochu et al. 2006; Arcus-Arth and Blaisdell 2007; and Stifelman 2007) to recommend the mean and 95th percentile values for inhalation in different age groups. The available studies on inhalation rates have been summarized by the EPA in the Exposure Factors Handbook published in 2011 (EPA 2011).

Table C-49 lists the recommended inhalation values for long-term exposure along with the inhalation values from other studies. The EPA-recommended mean values for inhalation rate vary from 5.4 m^3/d (for birth to <1 yr.) to 16.3 m^3/d (16 to <21 yr.). The EPA recommended mean values based on recent key studies are comparable to the values listed in Table C-47.

To select default values for RESRAD-ONSITE and RESRAD-OFFSITE, a resident farmer scenario is considered. The residential scenario defines three exposure situations or contexts: indoors, outdoors, and gardening. Table C-48 summarizes the recommended default values for each situation/context. Because of the wide variation in inhalation rates possible for the residential scenario, a triangular distribution was selected to represent the rate of the average member of the critical group. The most likely value was taken to be 8,400 m^3/yr (23 m^3/d) as recommended by Beyeler et al. (1998b) for the on-site residential scenario. A minimum value of 4,380 m^3/yr (0.5 m^3/h) was selected on the basis of recommendations for sedentary adult activities, and the maximum value of 13,100 m^3/yr (1.5 m^3/h) selected corresponds to moderate outdoor activities (see Table C-48). Figure C-33 displays the probability distribution function for inhalation selected for the residential scenario.

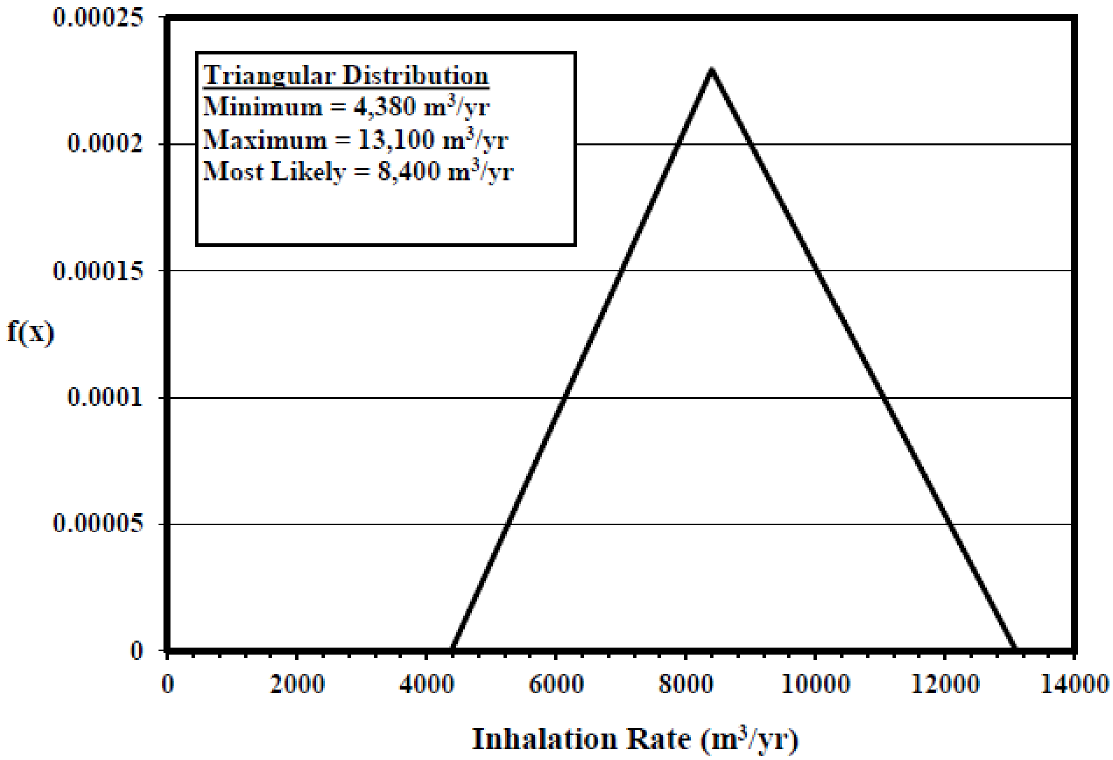

Figure C-33 Inhalation Rate Probability Density Function for RESRAD-ONSITE and RESRAD-OFFSITE

For the building occupancy scenario, a triangular distribution is also used as default for input to RESRAD-BUILD. The most likely inhalation rate value was taken to be 33.6 m^3/d (1.4 m^3/h) as recommended in Beyeler et al. (1998a). The minimum value of 12 m^3/d (0.5 m^3/h) was selected on the basis of recommendations for sedentary adult activities, and a maximum value of 46 m^3/d (1.9 m^3/h) was selected because it represented the highest average value reported in Beyeler et al. (1998a) for workers in light industry and falls within the range of moderate to heavy activities for both adults and outdoor workers (Table C-47). Figure C-34 displays the probability distribution function for inhalation selected for the building occupancy scenario.

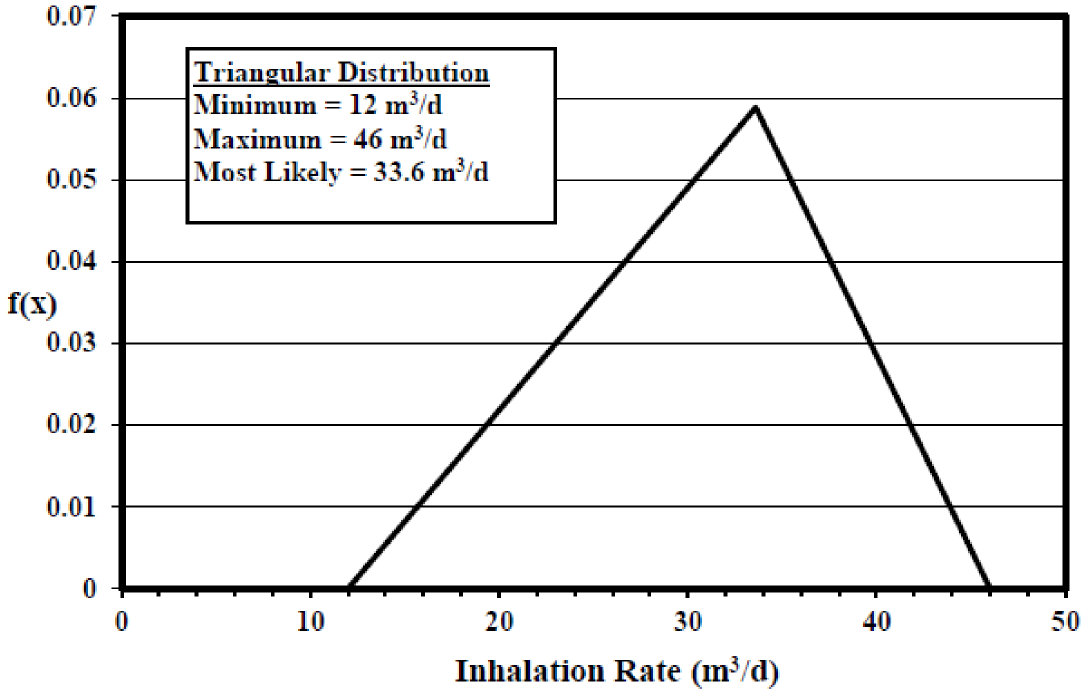

Figure C-34 Inhalation Rate Probability Density Function for RESRAD-BUILD

Table C-47 Summary of EPA's Recommended Values for Inhalation

Population	Mean	Population	Mean
Long-Term Exposures		*Short-Term Exposures*	
Infants (<1 year)	4.5 m^3/d	Adults	
		Rest	0.4 m^3/h
Children		Sedentary Activities	0.5 m^3/h
1–2 years	6.8 m^3/d	Light Activities	1.0 m^3/h
3–5 years	8.3 m^3/d	Moderate Activities	1.6 m^3/h
6–8 years	10 m^3/d	Heavy Activities	3.2 m^3/h
9–11 years			
Males	14 m^3/d	Children	
Females	13 m^3/d	Rest	0.3 m^3/h
12–14 years		Sedentary Activities	0.4 m^3/h
Males	15 m^3/d	Light Activities	1.0 m^3/h
Females	12 m^3/d	Moderate Activities	1.2 m^3/h
15-18 years		Heavy Activities	1.9 m^3/h
Males	17 m^3/d		
Females	12 m^3/d	Outdoor Workers	
		Hourly Average[a]	1.3 m^3/h
Adults (19-65+yrs)		Slow Activities	1.1 m^3/h
Females	11.3 m^3/d	Moderate Activities	1.5 m^3/h
Males	15.2 m^3/d	Heavy Activities	2.5 m^3/h

[a] Upper percentile = 3.3 m^3/h.
Source: EPA (1997).

Table C-48 Recommended Default Inhalation Rates for the Residential Scenario

Exposure Context/Parameter	Inhalation Rate (m^3/h)	Time Spent (days/year)
Indoors	0.9	240
Outdoors	1.4	40.2
Gardening	1.7	2.92
Average on-site rate	23 m^3/d	

Source: Beyeler (1998b).

Table C-49 EPA-Recommended Inhalation Values for Long-Term Exposure

Age Group	Recommended Mean (m^3/day)	Mean (m^3/day) from Key Studies				Recommended 95th percentile	95th percentile (m^3/day) from Key Studies		
		EPA (2009)	Brochu et al. (2006)	Arcus-Arth and Blaisdell (2007)	Stifelman (2007)		EPA (2009)	Brochu et al. (2006)	Arcus-Arth and Blaisdell (2007)
Birth to <1 year	5.4	8.64	3.72	5.7	3.4	9.2	12.67	4.9	9.95
1 to <2 years	8	13.41	4.9	8.77	4.9	12.8	18.22	6.43	13.79
2 to <3 years	8.9	12.99	7.28	9.76	5.7	13.7	17.04	9.27	14.81
3 to <6 years	10.1	12.4	7.28	11.22	9.3	13.8	1C.5.17	9.27	17.09
6 to <11 years	12	12.93	9.98	13.42	11.5	16.6	17.05	12.85	19.86
11 to <16 years	15.2	14.34	14.29	16.98	15	21.9	19.23	19.02	27.53
16 to <21 years	16.3	15.44	14.29	18.29	17	24.6	20.89	19.02	33.99
21 to <31 years	15.7	16.3	14.59	NA[a]	NA	21.3	23.57	19	NA
31 to <41 years	16	17.4	14.99	NA	NA	21.4	24.3	18.39	NA
41 to <51 years	16	18.55	13.74	NA	NA	21.2	24.83	17.5	NA
51 to <61 years	15.7	18.56	13.74	NA	NA	21.3	25.17	17.5	NA
61 to <71 years	14.2	15.43	12.57	NA	NA	18.1	19.76	16.37	NA
71 to <81 years	12.9	14.25	11.46	NA	NA	16.6	17.88	15.3	NA
81 years	12.2	12.97	11.46	NA	NA	15.7	16.1	15.3	NA

Note: Recommended values are the weighted average of key studies.
[a] NA = value not available.
Source: EPA (2011)

C.5.2 Drinking Water Intake

Applicable Code: RESRAD-ONSITE and RESRAD-OFFSITE

Description: The drinking water intake rate is defined as the average amount of water consumed by an adult per unit of time. It includes juices and beverages containing tap water (e.g., coffee).

Units: liters per year (L/yr)

Probabilistic Input:

Distribution: truncated lognormal-n

Defining Values for Distribution:

Underlying mean value: 6.015 Lower quantile value: 0.001

Underlying standard deviation0.489 Upper quantile value: 0.999

Discussion: The distribution of the drinking water intake rate generally varies from 0.10 to 3 L/d, depending on the age, body weight, and activity level of the receptor. Temperature and humidity levels also influence drinking water intake rates. A rigorous statistical treatment of water intake data for a large data set (n = 26,081; Ershow and Cantor, 1989) is provided by Roseberry and Burmaster (1992). Estimates are provided for (1) tap water intake (the sum of water drunk directly as a beverage and water added to foods and beverages during preparation) and (2) total water intake, which includes tap water intake and intrinsic water intake (i.e., the water intrinsic in foods as purchased). The values associated with tap water intake are more likely to apply for risk assessment purposes.

The mean and standard deviations for the underlying normal distribution for five age categories are provided by Roseberry and Burmaster (1992). Alternatively, the mean and standard deviation for the entire population may be used when intake over a lifetime is being evaluated. Finley et al. (1994) used the same data set to generate age-specific cumulative distributions for drinking water intake. The results of Roseberry and Burmaster (1992) are reported here (see Table C-50) because of ease of use in Monte Carlo analyses. The mean total tap water intake rates for the two adult populations (age 20 to 65 years, and 65+ years) were estimated to be 1.27 and 1.34 L/d, respectively.

Table C-50 Drinking Water Intake Rate Distributions

Distribution Type	Age Range	Mean	Standard Deviation	Comments
		Lognormal[a]		
Total water	<1	6.98	0.29	μ and SD of underlying normal distribution shown. Transforms to mL/d. Based on *n* = 26,081 (1.5 percent <1; 21.4 percent 1-<11; 22.2 percent 11-<20; 45 percent 20-<65; 9.7 percent >65).
	1 - <11	7.18	0.34	
	11 - <20	7.49	0.35	
	20 - <65	7.56	0.40	
	>65	7.58	0.36	
	Total	7.49	0.41	
Tap water	<1	5.59	0.62	
	1 - <11	6.43	0.50	
	11 - <20	6.67	0.54	
	20 - <65	7.02	0.49	
	>65	7.09	0.48	
	Total	6.86	0.58	

[a] 97.5 percentile intake rate = exp [$\mu + (1.96\sigma)$],
75 percentile intake rate = exp [$\mu + (0.6745\sigma)$],
50 percentile intake rate = exp [μ],
mean intake rate = exp [$\mu + 0.5\sigma^2$)].
Source: Roseberry and Burmaster (1992; based on 1977-1978 Nationwide Food Consumption Survey, USDA).

The American Industrial Health Council's (AIHC's) Exposure Factors Sourcebook (AIHC, 1994) presents drinking water intake recommendations for adults. The recommended mean drinking water intake is 1.4 L/d, and the reasonable "worst-case" value is 2.0 L/d.

In its Exposure Factors Handbook, the EPA (1997) has compiled the available studies on drinking water consumption rate. The EPA has classified the studies as either key studies or relevant studies on the basis of the applicability of their survey designs to exposure assessment of the entire United States population. On the basis of the results of the key studies, the recommended drinking water intake rates for different age groups/populations are shown in Table C-51. The table also presents the mean, 50th, 90th, and 95th percentile values.

Some of the recent nationwide surveys such as the Continuing Survey of Food Intake by Individuals (CSFII) or the National Health and Nutrition Examination Survey (NHANES) collect data on dietary intake in the United States population. EPA (2011) used the survey data to estimate the overall per capita consumption rate of different food types. The EPA (2011) has recommended that the average adult (>21 years) per-capita drinking water intake rate is 1 L/d, the 90th percentile drinking water intake rate is about 2.5 L/d, and the 95th percentile drinking water intake rate is about 3 L/d. Table C-52 lists the EPA-recommended drinking water intake rates for different age groups. The recommended mean drinking water intake rate of 1 L/d is much less than the value in Table C-52, however, the higher percentile values are comparable.

The age-specific rates for adults recommended by the EPA (1997) are based on data from the 1977-1978 USDA Nationwide Food Consumption Survey (EPA, 1984). The same data were used by Roseberry and Burmaster (1992) and by Ershow and Cantor (1989) to develop intake distributions. In addition, the lognormal distributions derived in Roseberry and Burmaster (1992) was recommended as a good mathematical description of drinking water intake by the EPA (1997). Given the fact that this EPA recommendation in 1997 is somewhat more conservative than the EPA recommendation in 2011, it is adopted for use in RESRAD-ONSITE and RESRAD-OFFSITE. Therefore, the suggested parameter distribution for drinking water intake in RESRAD-ONSITE and RESRAD-OFFSITE is taken to be the lognormal distribution for adults in Roseberry and Burmaster (1992). Adjusted for drinking rate input units of liters per year (409.5 L/yr), the adjusted underlying mean and standard deviation are 6.015 and 0.489, respectively. The probability density function is shown in Figure C-35.

Table C-51 Summary of Recommended Drinking Water Intake Rates

Age Group/ Population	Mean	Percentiles		
		50th	90th	95th
<1 yr.	0.30 L/day	0.24 L/day	0.65 L/day	0.76 L/day
	44 mL/kg-day	35 mL/kg-day	102 mL/kg-day	127 mL/kg-day
<3 yr.	0.61 L/day	-	1.5 L/day	-
3-5 yr.	0.87 L/day	-	1.5 L/day	-
1-10 yr.	0.74 L/day	0.66 L/day	1.3 L/day	1.5 L/day
	35 mL/kg-day	31 mL/kg-day	64 mL/kg-day	79.4 mL/kg-day
11-19 yr.	0.97 L/day	0.87 L/day	1.7 L/day	2.0 L/day
	18 mL/kg-day	16 mL/kg-day	32 mL/kg-day	40 mL/kg-day
Adults	1.4 L/day	1.3 L/day	2.3 L/day	
	21 mL/kg-day	19 mL/kg-day	34 mL/kg-day	
Pregnant women	1.2 L/day	1.1 L/day	2.2 L/day	2.4 L/day
	18.3 mL/kg-day	16 mL/kg-day	35 mL/kg-day	40 mL/kg-day
Lactating women	1.3 L/day	1.3 L/day	1.9 L/day	2.2 L/day
	21.4 mL/kg-day	21 mL/kg-day	35 mL/kg-day	37 mL/kg-day
Adults in high activity/ hot climate conditions	0.21 to 0.65 L/hour, depending on ambient temperature and activity level			
Active adults	6 L/day (temperate climate) to 11 L/day (hot climate)			

Source: EPA (1997).

Table C-52 EPA Recommended Drinking Water Intake Rates

Age Group	Per-capita Intake (mL/day)			
	Mean	50th Percentile	90th Percentile	95th Percentile
Birth to 1 month	184	0	687	839
1 to <3 months	227	0	804	896
3 to <6 months	362	148	928	1056
6 to <12 months	360	218	885	1055
1 to <2 yr.	271	188	624	837
2 to <3 yr.	317	246	683	877
3 to <6 yr.	327	245	746	959
6 to <11 yr.	414	297	1000	1316
11 to <16 yr.	520	329	1338	1821
16 to <18 yr.	573	375	1378	1783
18 to <21 yr.	681	355	1808	2368
>21 yr.	1043	787	2414	2958
>65 yr.	1046	886	2272	2730
All ages	869	560	2170	2717
Source: EPA (2011).				

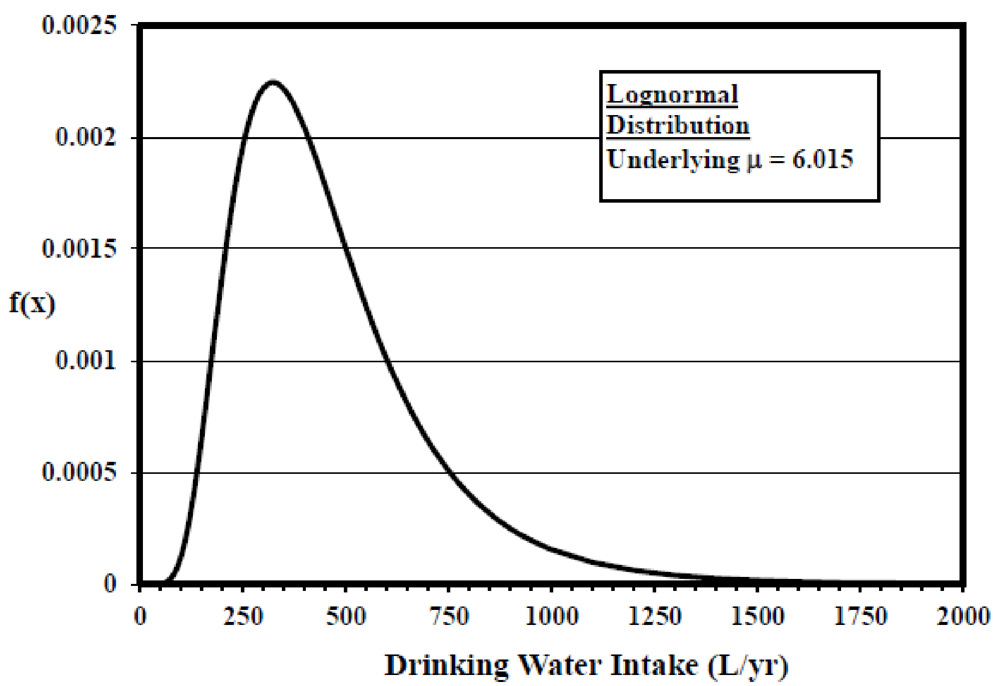

Figure C-35 Drinking Water Intake Probability Density Function

C.5.3 Milk Consumption

Applicable Code: RESRAD-ONSITE and RESRAD-OFFSITE

Description: The milk consumption rate is the amount of fluid milk (beverage) consumed per year.

Units: liters per year (L/yr)

Probabilistic Input:

Distribution: triangular

Defining Values for Distribution:

Minimum: 60 Maximum: 200 Most likely: 102

Discussion: The milk consumption rate can vary for different population groups, ages, and geographic locations. In RESRAD-ONSITE and RESRAD-OFFSITE, the consumption rate of milk is for fluid milk only. This rate is required by the RESRAD-ONSITE and RESRAD-OFFSITE computer codes when the milk ingestion pathway is active.

The EPA's Exposure Factor Handbook (EPA, 1997) provides milk consumption rates that were obtained from the USDA's National Food Consumption Survey (NFCS; USDA, 1980, 1992), Continuing Survey of Food Intakes by Individuals (USDA, 1996a,b), and Food Consumption, Prices and Expenditures 1970-1992 (USDA, 1993).

An indication of consumption rates for a variety of foodstuffs is provided in the USDA report Food Consumption, Prices, and Expenditures 1970-1997 (Putnam et al., 1999). The estimates of food for human consumption are derived by subtracting other measurable uses, such as exports, industrial uses, farm inputs, and end-of-year stocks, from total supply (the sum of domestic production, imports and beginning stocks; Putman et al., 1999). Hence, the data provided in this report would be an upper bound on human consumption assuming no spoilage or wastes. The food consumption rates are grouped by food categories, with several subcategories under the major categories (e.g., major category—dairy products, subcategory—beverage milk). Further information, such as the individual consumption rates for each food type, is provided in the report for each year reported (Putnam et al., 1999).

An average fresh milk consumption rate of 294 g/d was estimated by the NFCS for 1977-1978 (EPA, 1997). This average daily consumption value corresponds to an annual consumption rate of 104 L/yr averaged over all age brackets. The largest milk consumption rate was in the 10- to 14-year-old age range. This group consumed approximately 456 g/d (162 L/yr), which is over 2.5 times higher than the consumption rate of the age bracket (40-59) that consumed the least amount of milk. The age-bracketed milk consumption rates are provided in Table C-53 Mean per Capita Intake of Fresh Cow's Milk.

Some of the nationwide surveys, such as CSFII or NHANES, collect data on dietary intake in the U.S. population. The survey data were used by EPA (2011) to estimate the overall per capita intake rate of different food types. The per capita estimated means from the 1994 and 1995 CSFII surveys of milk intake in the United States were 229 g/d (84 L/yr) and 236 g/d (86 L/yr), respectively (EPA 2011). The estimated mean values for milk and milk products using1994–1996 and 1998 CSFII survey data were 477 g/d (174.1 L/yr) for children aged ≤5 years, 453 g/d (16C.5.3 L/yr) for children aged ≤9 years, and 405 g/d (147.8 L/yr) for children aged ≤19 years (EPA 2011). The estimated mean values are comparable to the values listed in Table C-53.

The USDA Food Consumption, Prices and Expenditures Report (Putnam, 1999) provides year-bracketed consumption rates for beverage milk for the years 1972–1997. The average beverage milk consumption rate was estimated to be approximately 101 L/yr, which agrees well with the NFCS data. Table C-54 provides the yearly milk consumption rate averaged in four-year intervals. The largest milk consumption rate in a four-year interval occurred from 1972–1976, when the per capita beverage milk consumption averaged 113 L/yr. After that time, per capita milk consumption declined to the 1997 value of 90 L/yr.

A triangular probability distribution was chosen for the milk consumption rate. The minimum value was taken to be 60 L/yr, which corresponded to the consumption rate of 40-59 age bracket of the NFCS study. The maximum milk consumption rate was set at 200 L/yr, which is equal to the fluid milk consumption rate stipulated in NRC RG 1.109 for a child (NRC, 1977). A value of 102 L/yr was chosen as the most likely value because it is the average of the NFCS and USDA values. Figure C-36 Milk Consumption Rate Probability Density Function shows the resulting probability density function for the milk consumption rate.

Table C-53 Mean Per Capita Intake of Fresh Cow's Milk

Age Group (yr)	Fluid Milk (g/d)
<1	272
1-4	337
5-9	446
10-14	456
15-19	405
20-24	264
25-39	218
30-39	183
40-59	169
60+	192
Average	294
Source: EPA (1997).	

Table C-54 Annual Per Capita Consumption of Beverage Milk

Year	Consumption (L/yr)
1972-1976	112
1977-1981	105
1982-1986	99
1987-1999	97
1992-1996	92
1997	93
Average (1972-1997)	101
Source: Derived from Putnam et. al. (1999).	

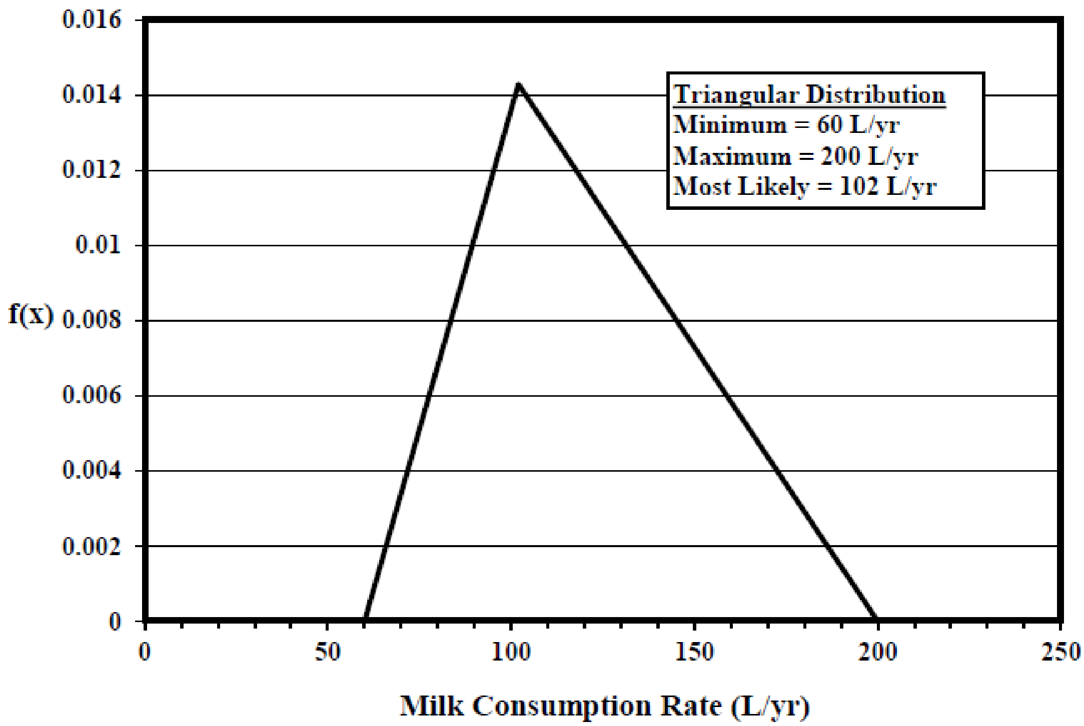

Figure C-36 Milk Consumption Rate Probability Density Function

C.5.4 Fruit Vegetable and Grain Consumption

Applicable Code: RESRAD-ONSITE and RESRAD-OFFSITE

Description: The fruit, vegetable, and grain consumption rate is the total quantity of these food items (contaminated and uncontaminated) consumed per year.

Units: kilograms per year (kg/yr)

Probabilistic Input:

Distribution: triangular

Defining Values for Distribution:

Minimum: 135 Maximum: 318 Most likely: 178

Discussion: The fruit, vegetable, and grain consumption rate can vary for different population groups, ages, and geographic locations. In RESRAD-ONSITE and RESRAD-OFFSITE, the consumption rate for fruits, vegetables, and grain is a composite value obtained by summing the individual consumption rates for fresh fruits, fresh vegetables (non-leafy), and grain.

The vegetable portion of this parameter does not include leafy vegetables consumed. Leafy vegetable consumption is a separate parameter in the RESRAD-ONSITE and RESRAD-OFFSITE computer codes (Yu et. al., 2001; Yu et al. 2018). In addition, the fruit, vegetable, and grain consumption rate should only apply to fresh fruits and vegetables. This parameter is used when the plant ingestion exposure pathway is active.

The EPA published the Exposure Factors Handbook (EPA, 1997) to summarize data on human behaviors and to recommend values to use in modeling those activities. The consumption rates for fruits, vegetables, and grain provided in the handbook were obtained from the USDA's National Food Consumption Survey (USDA, 1980, 1992), Continuing Survey of Food Intakes by Individuals (USDA, 1996a,b), and Food Consumption, Prices and Expenditures 1970-1992 (USDA, 1993).

The Exposure Factors Handbook (EPA, 1997) provides intake rates in units of grams of food consumed per kilogram of body weight per day. The data are grouped by age, season, urbanization (central city, nonmetropolitan, and suburban), race, and region (Midwest, Northeast, South, and West). Converting the intake rates into units of kg/yr by multiplying by a single average body weight is inappropriate because intake rates were indexed to the reported body weights of the survey respondents. An average adult body weight of approximately 72 kg was estimated by averaging the combined male-female body weights contained in Table 7-2 of the Exposure Factors Handbook (EPA, 1997). Since the results are grouped by age, the average consumption rate was derived for each food class on the basis of the dietary habits of adults (ages 20–70+). The average consumption rates on a per-kilogram-body-weight basis are provided in Table C-55 Median per Capita Intake of Total Fruits, Vegetables, and Grains (g/kg-d as consumed) for each age group.

An indication of food consumption for a variety of foodstuffs is provided in the USDA report Food Consumption, Prices, and Expenditures 1970-1997 (Putnam et al., 1999). The estimates of food for human consumption are derived by subtracting measurable uses such as exports, industrial uses, farm inputs, and end-of year stocks from total supply (the sum of domestic production, imports, and beginning stocks; Putnam et al., 1999). Hence, the data provided in this report would be an upper bound on human consumption assuming no spoilage or wastes.

The foods are grouped by totals, fresh fruits/vegetables, and major subcategories (citrus, noncitrus, etc.). Further information, such as the individual consumption rates for each food type, is provided in the report for each year reported (Putnam et al., 1999).

Fresh fruits and vegetables accounted for approximately 42 and 44 percen, respectively, of the total fruits and vegetables consumed during the 25-year period from 1972 through 1997

(Putnam et al., 1999). The fresh vegetable percentage remained relatively constant throughout the 25-year period, while the fresh fruit consumption rose from 40 percent from 1972–1976 to 45 percent in 1997. The fraction of non-leafy fresh vegetables consumed from 1972–1997 was estimated at 0.67 of the total fresh vegetable consumption rate. Table C-56 provides consumption values for fresh fruits, fresh vegetables, and grain for the years 1972-1997 (Putnam et al., 1999).

A probability distribution (triangular, see Figure C-37) for the fruit, vegetable, and grain consumption rate was derived from the information provided in the EPA Exposure Factor Handbook (EPA, 1997) and the USDA report Food Consumption, Prices, and Expenditures 1970-1997 (Putnam et al., 1999). The lower bound of the distribution was obtained by averaging the median per capita consumption rate for ages 20–70+ provided in Table C-55 and multiplying by the average weight of an adult. Correction factors of 0.42 and 0.44 were applied to the fruit and vegetable[2] consumption rate to account for the consumption of fresh fruits and vegetables only. A further correction factor of 0.67 was applied to the vegetable consumption rate to account for the intake of non-leafy vegetables only. These values were summed to yield a single consumption rate for fruit, vegetables, and grains. The upper bound of the distribution was estimated in the same manner, except the 95th percentile was used for the per-capita consumption rate instead of the median value. The average value of the total given in Table C-56 was used for the most likely value of the triangular distribution.

Table C-55 Median Per Capita Intake of Total Fruits, Vegetables, and Grains

Age Group (yr)	Total Fruits (g/kg-d consumed)	Total Vegetables (g/kg-d consumed)	Total Grains (g/kg-d consumed)
<1	14.9	6.8	7.0
1-2	11.8	7.9	10.6
3-5	8.4	7.1	9.5
6-11	5.0	5.5	6.4
12-19	2.2	3.8	3.8
20-39	1.9	3.5	3.1
40-69	2.1	3.7	2.8
70+	3	4.1	3.3

Source: EPA (1997).

[2] Nonleafy vegetables are all vegetables except cabbage, cauliflower, broccoli, celery, lettuce, and spinach (EPA, 1997).

Table C-56 Per Capita Consumption Values for Fresh Fruits, Fresh Vegetables, and Grains

Year	Fresh Fruits	Fresh Vegetables (Non-Leafy)	Grains	Total
1972–1976	45	45	63	152
1977–1981	47	43	65	154
1982–1986	51	46	69	166
1987–1999	54	50	81	185
1992–1996	57	55	88	200
1997	61	58	91	210
Average (1972-1997)	52	50	76	178
Source: Derived from Putnam et al. (1999).				

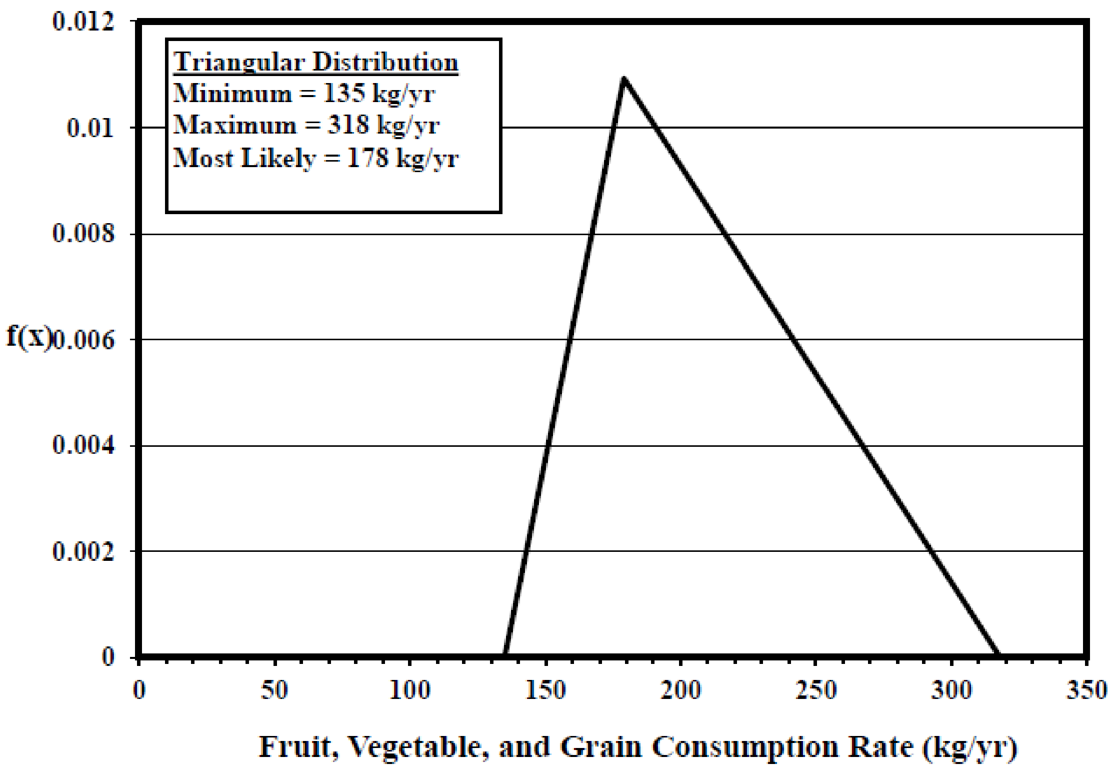

Figure C-37 Fruit, Vegetable, and Grain Consumption Rate Probability Density Function

C.5.5 Soil Ingestion Rate

Applicable Code: RESRAD-ONSITE and RESRAD-OFFSITE

Description: Ingestion rate of soil from outdoor activities.

Units: grams per year (g/yr)

Probabilistic Input:

Distribution: triangular

Defining Values for Distribution:

Minimum: 0 Maximum: 36.5 Most likely: 18.3

Discussion: The soil and dust ingestion rate varies over a wide range, depending on the age, activities, and possible dietary anomalies (e.g., pica, the desire to eat substances not normally eaten) of the receptor, and weather at the time of exposure. To date, most study has been focused on soil and dust ingestion rates for children aged 1–6 because of concern over elevated exposures from intensive mouthing behavior in children of this age group. Table C-5-7 summarizes selected work.

The best data are considered to come from studies that use a mass-balance approach to estimate ingestion rates. That approach measures unabsorbed tracer elements in soil, dust, and feces and accounts for other dietary sources of the tracers. Estimates of soil and dust ingestion rates for individuals vary from 0 mg/d (Calabrese et al., 1989) to 10 g/d (Kimbrough et al., 1984) for a child exhibiting pica. Information on the amount of soil ingested by children with abnormal soil ingestion behavior is limited. The Calabrese et al. (1991) study included one pica child among the 64 children who participated. In that study, a 3.5-year-old female exhibited extremely high soil ingestion behavior during one of the two weeks of observation. Intake ranged from 74 mg/d to 2.2 g/d during the first week and 10.1 to 13.6 g/d during the second week. These results were based on mass-balance analyses for seven tracer elements. Calabrese and Stanek (1992) concluded that the origin of the soil ingestion for the pica child was from outdoor soil, not from indoor dust. Median soil and dust ingestion rates for children in this age group are generally about 50 mg/d (Binder and Sokal, 1986; Calabrese et al., 1989; Davis and Waller, 1990; Thompson and Burmaster, 1991).

A strong inverse correlation of soil ingestion rate with precipitation has been documented (Van Wijnen et al., 1990), presumably related to the fact that precipitation decreases the opportunity for soil contact. However, no widely accepted method is currently available for determining the relative contribution of outdoor soil versus indoor dust to the daily total ingestion rate, and the effect of climatic variation has yet to be determined (EPA, 1991).

Calabrese et al. (1990) also estimated soil ingestion rates for adults by using a mass-balance approach. Although the number of subjects studied (six) was too small to be certain of the distribution type, the medians were considerably lower than the mean values, suggesting that the distributions are also lognormal, as has been noted for children. The EPA (1991) recommended that the median soil ingestion rate from this study that is based on aluminum as the tracer (i.e., 50 mg/d) be used as the point estimate for adult soil ingestion in occupational settings (except for construction work). A point value of 100 mg/d for adults in residential settings was recommended (EPA, 1989b); presumably, this increased value was intended to account for certain activities that would involve greater soil ingestion than was found in the Calabrese et al. (1990) study.

Calabrese et al. (1989) studied soil ingestion among 64 children between the ages of 1–4 years by using eight tracer elements. That study was conducted over eight days during a two-week period and used mass-balance methodology. On the basis of the three most reliable tracer elements, the mean soil intake rate for children was estimated to be 153 mg/d based on aluminum tracer, 154 mg/d based on silicon tracer, and 85 mg/d based on yttrium tracer. Median intake rates were somewhat lower (29 mg/d for aluminum, 40 mg/d for silicon, and 9 mg/d for yttrium), 95th percentile values were 223 mg/d for aluminum, 276 mg/d for silicon, and 106 mg/d for yttrium.

Table C-57 Soil and Dust Ingestion Rate Distributions

Distribution Type	μ	SD	Comments	References
Lognormal	91 mg/d	126 mg/d	Age 1–3. Mean and SD of underlying lognormal distribution shown. *n* = 65. Based on the combined data for Al and Si tracers.	Thompson and Burmaster, 1991; based on data from Binder and Sokal, 1986
Lognormal	153 mg/d	852 mg/d	Age 1–4. Median = 29 mg/d. Mean and SD of lognormal distribution shown (underlying normal mean and SD not given). *n* = 64. Based on data for Al tracer.	Calabrese et al., 1989
Normal	5.0—Daycare 5.2—Campers	0.81 - Daycare 0.55 - Campers	Age 1–4. Mean and SD of underlying normal distribution shown. *n* = 292 (daycare group); *n* = 78 (campers). Based on combined data for Al, Ti, and acid-insoluble residue tracers.	Van Wijnen et al., 1990
Lognormal	Al-39 mg/d Si-82 mg/d	Al-145 mg/d Si-123 mg/d	Age 2–7 (42 percent ≤4 years old). Mean and SD of lognormal distribution shown (underlying normal mean and SD not given). *n* = 101. Based on data for Al and Si tracers.	Davis and Waller, 1990
Normal	195 mg/d	53 mg/d	Age applicable to 2-year-olds. Although underlying distributions were not normal, the reported values are the mean and SD of mean rates obtained with different tracers, so this distribution approaches the normal (Central Limit Theorem). Based on data for Al, Si, Ti, V and Y tracers.	Sedman and Mahmood, 1994; based on data from Calabrese et al., 1989 and Binder and Sokal, 1986
Lognormal	Al-77 mg/d Si-5 mg/d	Al-65 mg/d Si-55 mg/d	Age 25–41. Mean and SD of lognormal distribution shown (underlying normal mean and SD not given). *n* = 6. Based on data for Al and Si tracers.	Calabrese et al., 1990
Lognormal	10 mg/d	94 mg/d	Age—Adults. *n* = 10. Mass balance studies on 10 adults over a period of 28 days.	Stanek et al., 1997

Van Wijnen et al. (1990) studied soil ingestion among Dutch children aged 1–5 years old by using a tracer element methodology. A total of 292 children attending daycare centers were sampled during the first of two sampling periods, 187 children in the second , and 162 children for both periods. A total of 78 children attending camps were sampled, and 15 hospitalized children were sampled. The mean value for these groups were 162 mg/d for children in daycare centers, 213 mg/d for campers, and 93 mg/d for hospitalized children. The soil intake rates were found to be skewed, and the log transformed data were approximately normally distributed. Geometric means were 111, 174, and 74 mg/d for daycare, camping, and hospitalized children, respectively. Van Wijnen et al. (1990) suggest that the mean value for hospitalized infants represents background intake of tracers and should be used to correct the soil intake rates for other sampling groups. Using mean values, corrected soil intake rates were 69 mg/d for daycare children and 120 mg/d for campers.

Davis and Waller (1990) used a mass-balance/tracer technique to estimate soil ingestion among children. In that study, 104 children between the ages of 2–7 were randomly selected from a three-city area in southeastern Washington State. Soil ingestion rates were highly variable, especially those based on titanium. This study also evaluated the extent to which differences in tracer concentrations in house dust and yard soil affected soil ingestion rate estimates. The adjusted mean soil/dust intake rates were 64.5 mg/d for aluminum, 160 mg/d for silicon, and 268.4 mg/d for titanium. Adjusted median soil/dust intake rates were: 51.8 mg/d for aluminum, 112.4 mg/d for silicon, and 116.6 mg/d for titanium. This study was conducted over a one-week period.

Thompson and Burmaster (1991) developed parameterized distributions of soil ingestion rates for children based on a reanalysis of the data collected by Binder and Sokal (1986). The mean intake rates were 97 mg/day for aluminum, 85 mg/day for silicon, and 1,004 mg/day for titanium. On the basis of the arithmetic average of aluminum and silicon for each child, mean soil intake was estimated to be 91 mg/day. Statistical testing of the data indicated that only silicon and the average of the silicon and aluminum tracers were lognormally distributed with median = 59 mg/d, standard deviation = 126, and arithmetic mean = 91 mg/d.

Sedman and Mahmood (1994) used the results of two children's tracer studies (Calabrese et al., 1989; Davis and Waller, 1990) to estimate average daily soil ingestion in young children and for a lifetime. The average ages of children were 2.4 and 4.7 years, respectively, in these two studies. The mean of the adjusted levels of soil ingestion for a two-year-old child was 220 mg/d for the Calabrese et al. (1989) study and 170 mg/d for the Davis and Waller (1990) study. From the adjusted soil ingestion estimates, based on a normal distribution of means, the mean estimate for a two-year-old child was 195 mg/d, and the standard deviation of mean was 53 mg/d.

Stanek and Calabrese (1995) recalculated ingestion rates that were estimated in three mass-balance studies (Calabrese et al., 1989; Davis and Waller, 1990 for children's soil ingestion; Calabrese et al., 1990 for adult soil ingestion) using the best tracer method (BTM). This method allows for the selection of the most recoverable tracer for a particular subject or group of subjects. For adults, Stanek and Calabrese (1995) used data for eight tracers from the Calabrese et al. (1990) study to estimate soil ingestion by the BTM. On the basis of the median of the soil ingestion rates for the best four tracer elements, the average adult soil ingestion rate was estimated to be 64 mg/d, with a median of 87 mg/d. The 90th percentile soil ingestion was 142 mg/d (18 subject weeks for 6 adults). For children, Stanek and Calabrese (1995) used data on eight tracers from Calabrese et al. (1989) and data on three tracers from Davis and Waller (1990) to estimate soil ingestion rates. On the basis of the median of soil ingestion estimates from the best four tracers in the Calabrese et al. (1989) study, the mean soil ingestion rate was 132 mg/d, and the median was 33 mg/d. The 95th percentile value was 154 mg/d (128 subject weeks for 64 children).

For the 101 children in the Davis and Waller (1990) study, the mean soil ingestion rate was 69 mg/d and the median was 44 mg/d. The 95th percentile estimate was 246 mg/d. When the Calabrese et al. (1989) and Davis and Waller (1990) studies were combined, the soil ingestion was estimated to be 113 mg/d (mean); 37 mg/d (median); and 217 mg/d (95th percentile), using BTM.

Sheppard (1995) summarized the available literature on soil ingestion to estimate the amount of soil ingestion in humans for the purposes for risk assessment. He categorized the available soil ingestion studies into two general approaches: (1) those that measured the soil intake rate with the use of tracers in the soil and (2) those that estimated soil ingestion based on activity (e.g., hand-to-mouth) and exposure duration. Sheppard assumed that the data from the previous studies were lognormally distributed because of the broad range, the concept that soil ingestion is never zero, and the possibility of very high values. The geometric mean for soil ingestion rate for children under 6 was estimated to be 100 mg/d. For children above 6 and adults, it was estimated to be 20 mg/d.

Stanek et al. (1997) studied soil ingestion in 10 adults (5 males, 5 females) in the age range of 22–45 years during the months of September through November by using the mass-balance approach. Soil ingestion estimates indicated that the average adult ingested 10 mg/d of soil, the upper 95th percentile value was 331 mg/d.

Simon (1998) reviewed much of the available literature on soil ingestion and lists a set of soil ingestion parameters for nine different lifestyle scenarios for adults and children. Values are listed for inadvertent soil ingestion and also for geophagia[3] (intentional soil ingestion). Table C-58 Soil Ingestion Model Parameters for Various Lifestyle Scenarios gives the soil ingestion parameters for various lifestyle scenarios from the Simon (1998) study. These parameter values are presented either as triangular distributions, specified as Tri (minimum, mode, maximum) or lognormal distributions, specified as LN (geometric mean, geometric standard deviation).

Lifestyle scenarios 1–7 may apply to localized populations within the United States or elsewhere, depending on the knowledge or judgment of the risk assessor. Lifestyle scenarios 8 and 9 would have greater applicability for scenarios outside of the United States. Simon (1998) assigned lognormal distributions to represent inadvertent ingestion for children and adults and triangular distributions for geophagia among adults and children. For the United States population, suggested inadvertent ingestion geometric mean values vary from 0.05 g/d to 0.2 g/d for adults and 0.1 g/d to 0.2 g/d for children. The geometric standard deviation of 3.2 was assigned for adults and 4.2 for children.

Beyeler et al. (1998b), upon review of the adult studies, proposed a triangular distribution with a most likely value of 50 mg/d for the residential farmer scenario and with minimum and maximum values of 0 and 100 mg/d, respectively. As noted in these reports, these estimates are highly uncertain because of the limited data available. The same triangular distribution proposed in Beyeler et al. (1998b) is suggested for use in RESRAD-ONSITE and RESRAD-OFFSITE for the residential farmer scenario. The probability density function is shown in Figure C.5.5-1. The average of 50 mg/d (18.3 g/yr) is above the 10 mg/d found in the most comprehensive adult study to date (Stanek et al., 1997), but needs to account for the outdoor lifestyle of a residential farming scenario.

After reviewing the data available in 2011, the EPA (2011) used the studies of Vermeer and Frate (1979) and Davis and Mirick (2006) as the key studies in estimating the adult soil and dust ingestion rates and reconfirmed the soil + dust ingestion value of 50 mg/d recommended as the standard default value for adult soil ingestion in 1991 (EPA 1991) Table C-59 EPA

[3] Geophagia is defined to be a condition in which the patient eats inedible substances, as chalk, clay or earth. It is agreed by many that geophagia or earth eating is a special case of pica.

Recommended Values for Daily Intake of Soil, Dust, and Soil + Dust lists the recommended values for daily intake of soil and dust (EPA 2011).

Table C-58 Soil Ingestion Model Parameters for Various Lifestyle Scenarios

Lifestyle Scenarios	Adult		Child (ages 1–6 yr.)	
	Inadvertent Ingestion (g/d)	Geophagia (g/d)	Inadvertent Ingestion (g/d)	Geophagia (g/d)
Occupations on tilled agriculture land (no homes)—bare part of year, vegetated part of year (Scenario 1)	LN (0.1, 3.2)	0	0	0
Occupations on pasture land (no homes)—heavily vegetated (Scenario 2)	LN (0.05, 3.2)	0	0	0
Occupations on pasture land (no homes)—sparsely vegetated, range land for grazing (Scenario 3)	LN (0.1, 3.2)	0	0	0
Occupations at construction sites (no homes)—distributed by earth-moving, traffic, bulldozing, etc. (Scenario 4)	LN (0.1, 3.2)	0	0	0
Rural lifestyles (with homes)—heavily vegetated, forests and fields (Scenario 5)	LN (0.1, 3.2)	Tri (1.0, 3.0, 5.0)	LN (0.1, 4.2)	Tri (1.0, 3.0, 5.0)
Rural lifestyles (with homes)—sparsely vegetated (Scenario 6)	LN (0.2, 3.2)	Tri (1.0, 3.0, 5.0)	LN (0.2, 4.2)	Tri (1.0, 3.0, 5.0)
Suburban lifestyles (with homes)—including lawns, parks, recreational areas, some gardens (Scenario 7)	LN (0.1, 3.2)	Tri (1.0, 3.0, 5.0)	LN (0.2, 4.2)	Tri (1.0, 3.0, 5.0)
Lifestyles of indigenous peoples (mainly hunters/food gathering/nomadic societies)—wet climates/regions of thick ground vegetation (Scenario 8)	LN (1.0, 3.0)	Tri (1.0, 3.0, 10.0)	LN (3.0, 4.0)	Tri (2.0, 5.0, 10.0)
Lifestyles of indigenous peoples (mainly hunters/food gathering/nomadic societies)—dry climates/regions of sparse ground vegetation (Scenario 9)	LN (2.0, 3.0)	Tri (1.0, 3.0, 10.0)	LN (3.0, 4.0)	Tri (2.0, 5.0, 10.0)

Table C-59 EPA Recommended Values for Daily Intake of Soil, Dust, and Soil + Dust

Age Group	Soil (mg/day)				Dust (mg/day)		Soil + Dust (mg/day)	
	Mean/ Median	Upper Percentile	Soil-Pica	Geophagy	Mean/ Median	Upper Percentile	Mean/ Median	Upper Percentile
6 week to <1 yr.	30				30		60	
1 to <21 yr.	50	200		50,000	60		100	200
Adult	20			50,000	30		50	

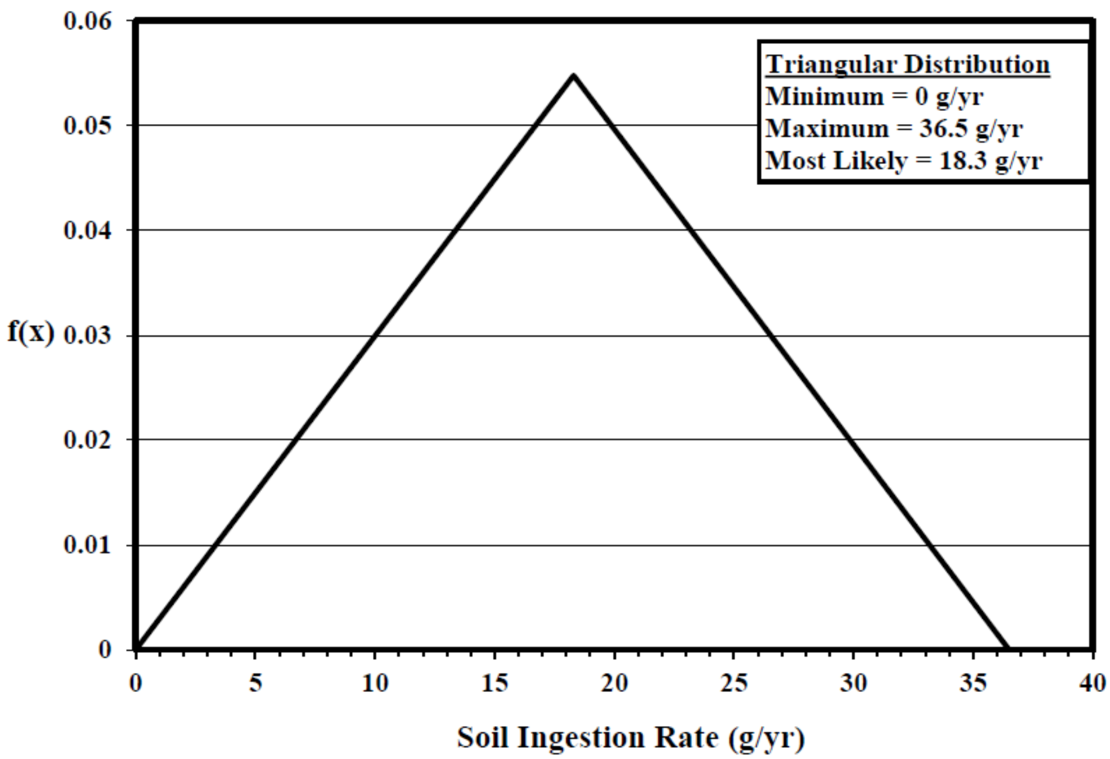

Figure C-38 Soil Ingestion Rate Probability Density Function

C.5.6 Indirect Ingestion Rate

Applicable Code: RESRAD-BUILD

Description: This parameter represents the ingestion rate of deposited material for a receptor at a specified location inside the building. This rate represents the transfer of deposited contamination from building surfaces to the mouth via contact with hands, food, or other objects. The indirect ingestion rate is expressed as the surface area contacted per unit time. This rate is different from the direct ingestion rate, since an individual does not need to be in the same room as the source to be exposed by this pathway.

Units: m^2/h

Probabilistic Input:

RESRAD-BUILD

Distribution: loguniform

Minimum: 2.8E-05 Maximum: 2.9E-04

Discussion: Only limited information is available on the values for this parameter. As reported in Beyeler et al. (1998), only eight data references are available (Dunster 1962; Gibson and Wrixon 1979; Healy 1971; Kennedy et al. 1981; Sayre et al. 1974; Lepow et al. 1975; Walter et al. 1980; Gallacher et al. 1984). However, half of these studies concerned intake by children, not adults in an occupational setting. A larger, secondary set of data from soil ingestion studies is available (see Section C.5.5). Again, however, the primary emphasis has been soil ingestion rates of children because of concern over elevated exposures from intensive mouthing behavior in this age group. Only two studies (Calabrese et al. 1990; Stanek et al. 1997) have provided empirical data for soil ingestion by adults. Comprehensive reviews of soil ingestion by humans can be found in Yu et al. (2015), EPA (2011), and Simon (1998).

Because the indirect ingestion rate is specified as the surface area contacted per unit time, estimates of the daily ingested amount were converted to the proper units by using estimates for deposited contamination (soil) concentrations on surfaces and soil loadings on the hand (Beyeler et al. 1998). Thus, a large uncertainty for the indirect ingestion rate is expected; in fact, the uncertainty is larger than the anticipated variability across sites (Beyeler et al. 1998). For this reason, Beyeler et al. (1998) have proposed two alternative distributions. However, Beyeler's suggested procedure produces an effective ingestion rate. It incorporates the number of hand-to-mouth events per day and transfer efficiencies between surface-to-hand and hand-to-mouth, because these factors were not explicitly accounted for in the calculation.

The two alternative distributions were proposed on the basis of mean ingestion rates of 0.5 and 50 mg/d. These rates fall within the 0–70 mg/d range for mean ingestion rates thought to be consistent with the empirical data (Calabrese et al. 1990; Calabrese and Stanek 1995; Stanek et al. 1997). The minimum and maximum ingestion rates were taken to be 0 and 200 mg/d, respectively. In the most comprehensive study, 10 subjects were followed for 28 days, yielding an average ingestion rate of 10 mg soil/d, with an upper 95 percent value of 331 mg soil/d (Stanek et al. 1997). Dust loadings were assumed to range from 10 mg/m^2, taken to be the lower limit in a residential setting, to 5,000 mg/m^2, taken to correspond to heavily soiled hands.

The resulting loguniform distributions (Table C-60) for the indirect ingestion rate parameter ranged from 4.4E-04 to 4.6E-03 m^2/d, with a mean of 1.8E-03 m^2/d; and from 5.1E-02 to 4.3E-01 m^2/d, with a mean of 1.8E-01 m^2/d. For use in RESRAD-BUILD, a 16-hour day was assumed, resulting in distributions with means of 1.1E-04 and 1.1E-02 m^2/h for the low and high average ingestion rate distributions presented in Table C-60. As discussed in Beyeler et al. (1998), an ingestion rate corresponding to 1.0E-02 m^2/h implies mouthing an area equivalent to the inner surface of the hand once each hour. Such an ingestion rate appears to be an upper bound for a commercial environment. Because adult ingestion rates can often approach zero (the lower bound), the lower ingestion rate distribution has been selected as a default for use in RESRAD-BUILD. Figure C-39 presents the probability density function.

The code requires that the average indirect ingestion rate in m^2/h be defined for each receptor location. The default deterministic value of 0.0001 m^2/h is consistent with the mean value of the default probabilistic input distribution. Setting this parameter to zero effectively suppresses the indirect ingestion pathway.

Table C-60 Indirect Ingestion Rates

Parameter	Mean	Lower Limit	Upper Limit
From Beyeler et al. 1998			
Dust loading (mg/m^2)	320	10	5,000
Low ingestion rate input (mg/d)	0.50	0	200
High ingestion rate input (mg/d)	50	0	200
Low ingestion rate estimate (m^2/d)	1.8E-03	4.4E-04	4.6E-03
High ingestion rate estimate (m^2/d)	1.8E-01	5.1E-02	4.3 0E-01
RESRAD-BUILD Input[a]			
Low ingestion rate estimate (m^2/h)	1.1E-04	2.8E-05	2.9E-04
High ingestion rate estimate (m^2/h)	1.1E-02	3.2E-03	2.7E-02

[a] Assumes a 16-hour day using the results from Beyeler et al. (1998).

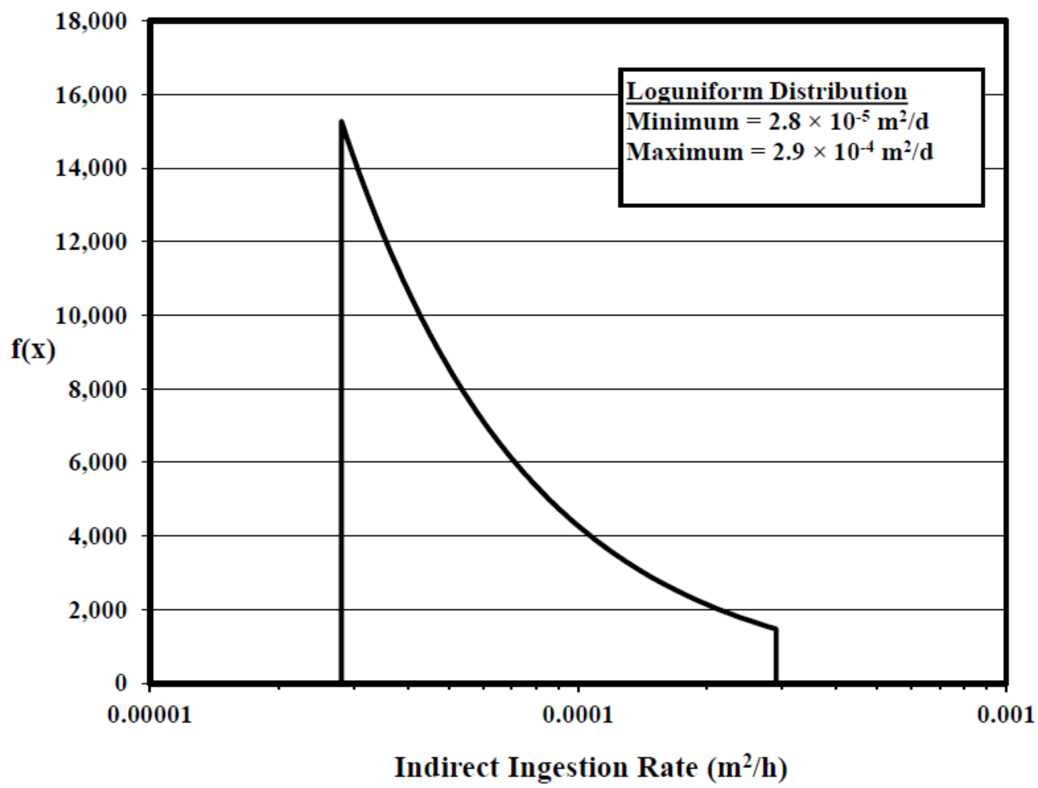

Figure C-39 Indirect Ingestion Rate Probability Density Function

C.5.7 Direct Ingestion Rate

Applicable Code: RESRAD-BUILD

Description: “Direct ingestion” refers to the incidental ingestion of contaminated material directly from the source.

Units: g/h for volume sources, 1/h for point, line, and area sources

Probabilistic Input:

RESRAD-BUILD

Distribution: none recommended

Discussion: This is the direct ingestion rate of the source by any receptor in the room. Each receptor will ingest the source at a rate determined by the product of the ingestion rate and the amount of contamination in the source at that time. Direct ingestion is possible only if the receptor and the source are in the same room. The direct ingestion rate is included in the RESRAD-BUILD code for unlikely events when a receptor could directly ingest source material. Such a receptor could be conducting a maintenance or renovation activity that involved physical contact with the source. The direct ingestion rate is normally set to 0 for most calculations.

The magnitude of the direct ingestion rate is highly correlated with other input parameters. For volume sources, the total amount of material ingested may range from 0 to a maximum specified by the mass of the source (area × thickness × density). In addition, the direct ingestion rate cannot exceed the amount removed per unit time as determined by the source erosion rate. Indirect ingestion (Section C.5.6) must also be taken into account, as must time spent in the room with the source. Also, the direct ingestion rate should not cause the total physical mass of the source to be depleted over the time of exposure and must take into account the mass balance because of erosion of the source resulting from other mechanisms.

For the other source types (point, line, and area), the direct ingestion rate is expressed as a fraction of the source ingested per hour. This rate may range from 0 to a value less than or equal to the removal rate that is determined by the removable fraction (Section C.8.3) and the source lifetime (Section C.8.7) input parameters. If the direct ingestion rate is large enough to match the removal rate, then the air release fraction (Section C.8.5) input must be set to 0 to maintain mass balance.

C.5.8 Quantity of Water for Household Purposes

Applicable Code: RESRAD-OFFSITE

Description: The quantity of water for household purposes is the average amount of water used indoors by an individual (per capita indoor water use).

Units: liters per day (L/day)

Probabilistic Input:

Distribution: truncated lognormal-n

Defining Values for Distribution:

Mean value: 5.51 | Lower quantile value: 0.001

Standard deviation: 0.407 | Upper quantile value: 0.999

Discussion: The indoor water use at a residential dwelling typically comes from toilets, clothes washers, baths and showers, sinks, leaks, dishwashers, and other miscellaneous uses. The total amount of water used on a daily basis is dependent upon a number of variables including geographic location, time of year, the number of persons sharing the residence, and the water efficiency of the fixtures and appliances. Table C-61 lists the average daily per capita water use in a residential setting for a number of past studies. Earlier work was also presented in Nazaroff et al. (1988), who summarized past work in the 1960s and 1970s, fitting a lognormal distribution to the available data with a geometric mean of 189 L/day for the per capita indoor use rate.

The latest study with the most extensive information available on residential water use is the Residential End Use of Water Study (REUWS; Mayer et al., 1999). The study was funded by the American Water Works Association Research Foundation and 22 municipalities, water utilities, water purveyors, water districts, and water providers. The goals of the study included the development of predictive models of water use, discerning differences between geographic locations, disaggregating indoor and outdoor water use, and looking at variations in water usage by different fixtures and appliances. The REUWS looked at 12 different locations in North America, sampling approximately 100 single-family homes at each location for a continuous period of 2 weeks in the summer and 2 weeks in the winter. Sampling was accomplished by using data loggers connected to water flow meters in each residence. Table C-62 lists the average per capita indoor water use at each site.

Figure C-40 displays a histogram of the per capita water use frequency distribution from the REUWS (Mayer, 2005) in conjunction with the probability distribution function for use in RESRAD-OFFSITE. The probability density function was fit well to a lognormal distribution by using nonlinear least squares regression analysis.

Table C-61 Past Studies on Per Capita Indoor Water Use

Study	Number of Residences	Study Duration (months)	Average (liters/person/ day)	Range (liters/person/ day)
Brown & Caldwell (1984)	210		250.6	216.9–276.3
Anderson and Siegrist (1989)	90	3	268	249.4–289.9
Anderson et al. (1993)	25	3	191.9	98.9–322.5
Mayer et al. (1999)	1,188	1	262.3	216.1–316.1
Weighted average	153		259.7	
Source: EPA (2002).				

Table C-62 Per Capita Indoor Water Use for the 12 Sites in the REUWS

Study Site	Sample Size (Number of households)	Mean Persons per Household	Mean Daily per Capita Indoor Use (liters/person/ day)	Median Daily per Capita Indoor Use (liters/person/ day)	Standard Deviation of per Capita Indoor Use (liters/person/ day)
Seattle, WA	99	2.8	216	204	108
San Diego, CA	100	2.7	221	205	88.6
Boulder, CO	100	2.4	245	228	97.7
Lompoc, CA	100	2.8	249	212	126
Tampa, FL	99	2.4	249	223	127
Walnut Valley Water District, CA	99	3.3	257	240	117
Denver, CO	99	2.7	262	246	132
Las Virgennes MetropolitanWater District, CA	100	3.1	263	231	146
Waterloo and Cambridge, ON	95	3.1	267	225	169
Phoenix, AZ	100	2.9	294	253	170
Tempe and Scottsdale, AZ	99	2.3	308	240	256
Eugene, OR	98	2.5	316	242	261
12 study sites	1188	2.8	262	229	150
Source: Mayer et al. (1999).					

As seen in Table C-61 and Table C-62, there is some variation in the per capita indoor water use. Some of this variation within and among sites can be attributed to regional personal use habits, additional individuals at home during the study period, or the prevalence of water-efficient appliances or reduced-flow fixtures (Mayer et al., 1999). Table C-63 presents a breakdown of water use among fixture and appliance use for each of the 12 sites. Additional information on the presence of fixtures/appliances, usage events, flow rates, and the demographics of the study participants can be found in Mayer et al. (1999).

Further work using methods similar to those in the REUWS to monitor indoor water usage relevant to water-conserving fixtures has also been published for Seattle, Washington (Mayer et al., 2000); Tampa, Florida (Mayer et al., 2004); and the San Francisco Bay area (Mayer et al., 2003). More information on specific water fixture uses can be found in EPA (1997) for most indoor uses, and a more detailed analysis for specific uses can be found in Burmaster (1998) (showering) and Wilkes et al. (2005; showering and bathing water use).

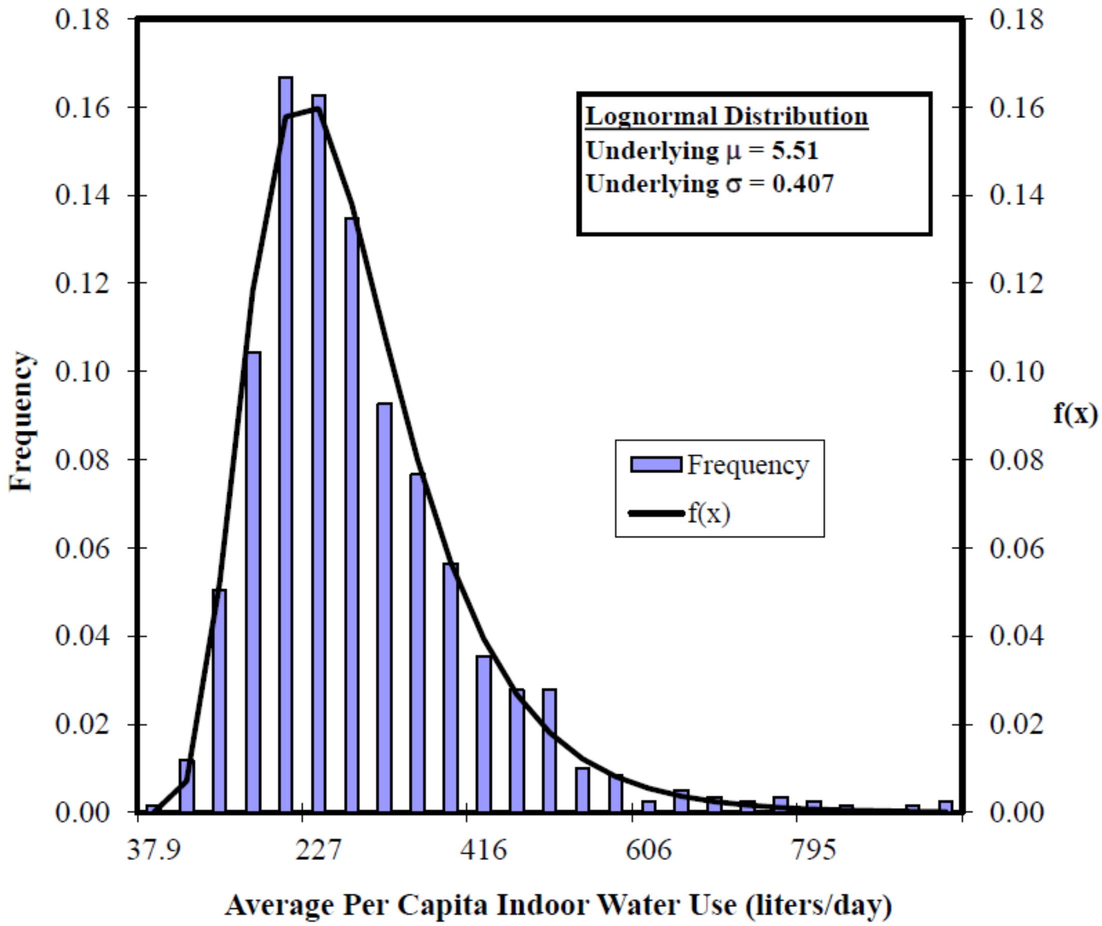

Figure C-40 Quantity of Water for Household Purposes Probability Density Function

Table C-63 Breakdown of Per Capita Indoor Water Use

Study Site	Toilet	Clothes Washer	Shower	Faucet	Leak	Other Domestic	Bath	Dishwasher
Seattle, WA	17.100	12.0	11.4	8.7	5.9	0.0	1.1	1.0
San Diego, CA	15.800	16.3	9.0	10.8	4.6	0.3	0.5	0.9
Boulder, CO	19.8	14.0	13.1	11.6	3.4	0.2	1.4	1.4
Lompoc, CA	16.6	15.3	11.1	9.9	10.1	0.9	1.2	0.8
Tampa, FL	16.700	14.2	10.2	12.0	10.8	0.3	1.1	0.6
Walnut Valley Water District, CA	18	14.1	11.7	12.3	7.6	2.3	1.0	0.8
Denver, CO	21.1	15.6	12.9	10.5	5.8	0.5	1.6	1.2
Las Virgennes Metropolitan Water District, CA	15.7	16.8	11.4	11.2	11.2	1.1	1.3	0.9
Waterloo and Cambridge, ON	20.3	13.7	8.3	11.4	8.2	6.0	1.9	0.8
Phoenix, AZ	19.6	16.9	12.5	9.6	14.8	2.2	1.2	0.8
Tempe and Scottsdale, AZ	18.4	14.5	12.6	11.2	17.6	5.0	0.9	1.1
Eugene, OR	22.9	17.1	15.1	11.9	13.6	0.1	1.5	1.4
12 study sites	18.5	15.0	11.6	10.9	9.5	1.6	1.2	1.0
Source: Mayer et al. (1999).								

C.5.9 Indoor Fraction

Applicable Code: RESRAD-BUILD, RESRAD-ONSITE, and RESRAD-OFFSITE

Description: The indoor fraction is the fraction of time an individual spends inside the residence (ONSITE and OFFSITE) or the contaminated building (BUILD).

Units: no units

Probabilistic Input:

Distribution: user-defined continuous with linear interpolation

Defining Values for Distribution: See Table C-64 for the input values.

Discussion:

In RESRAD-BUILD, the indoor fraction is used in the exposure calculations to calculate the amount of time spent at each receptor location. Actual exposure times at each location are estimated by multiplying the exposure duration by the indoor fraction and the fraction of time at the receptor location.

With the exposure duration given in units of days in RESRAD- BUILD, the indoor fraction is represented by the fraction of the day an individual spends indoors at work in the case of occupational exposure. Beyeler et al. (1998a) examined records from the Bureau of Labor Statistics (BLS) concerning the hours at work for persons employed in the agriculture and non-agriculture industries (BLS, 1996). The distribution given in Table C-65 was based on the assumption that full time nonagricultural workers spent 35 hours or more at work. However, some workers may spend some time outside.

The EPA's Exposure Factors Handbooks (EPA, 1997 and EPA, 2011) contain comprehensive review of human activity patterns, including time spent at work. That review extract data for time spent at work from the most complete and current study on activity patterns (Tsang and Klepeis, 1996). Table C-66 summarizes a number of distributions including distributions for time spent indoors at unspecified work locations in a plant/factory/warehouse. The distribution for full time workers in the plant/factory/warehouse category is expected to be the best representative for workers in the building occupancy scenario and is chosen as the default for RESRAD-BUILD. For perspective, the 50th percentile value for this distribution, 0.365, corresponds to an 8.76-hour work day. The cumulative distribution function for the indoor fraction is shown in Figure C-41.

The RESRAD-ONSITE and RESRAD-OFFSITE codes can be used to analyze many potential exposure scenarios, such as subsistence farmer, suburban resident, industrial worker, and recreationist. For the scenarios, the fraction of time spent indoors should be representative to the activity pattern associated with the scenario. The sum of the fraction of time spent indoors onsite, the fraction of time spent outdoors onsite, and the fraction of time spent off-site (only required as input in RESRAD-OFFSITE) should not exceed 1.

For the RESRAD-ONSITE and RESRAD-OFFSITE codes, the indoor fraction is the fraction of time spent inside the building where the receptor is shielded from the contaminated soil. This situation translates into the amount of time spent indoors at a residence when evaluating the residential farmer scenario, the default scenario. The EPA's comprehensive review of human activity patterns (EPA 2011) also contains statistics on the amount of time spent indoors at a residence. Table C-67 summarizes the relevant subset of distributions provided in the Exposure Factors Handbook (EPA 2011) for this time fraction. The distribution chosen to represent the average members of the critical group in the residential farmer scenario was that for the 18–64 age group. The table also lists distributions for other age groups. Figure C-42 presents the cumulative distribution function for the indoor fraction parameter in RESRAD- ONSITE and RESRAD-OFFSITE codes.

Table C-64 Cumulative Distribution Functions for the Indoor Fraction

Cumulative Probability	Indoor Fraction	
	ONSITE, OFFSITE	BUILD
0	0	3.00E-03
0.05	0.375	3.47E-02
0.25	0.521	3.06E-01
0.5	0.625	3.65E-01
0.75	0.809	4.03E-01
0.9	0.938	4.69E-01
0.95	0.992	5.00E-01
0.98	1	5.42E-01
0.99	1	5.94E-01
1	1	6.92E-01

Table C-65 Relative Frequency of Hours Worked by Persons Working 35 Hours or More per Week

Hours Worked per Week	Relative Frequency	Assuming a 5-Day Work Week	
		Hours per Day	Fraction of Day
35–39	9.96E-02	7-7.8	0.325
39–41	4.81E-01	7.8-8.2	0.342
41–48	1.59E-01	8.5-9.6	0.4
49–59	1.53E-01	9.8-11.8	0.492

Source: Beyeler et al. (1998a).

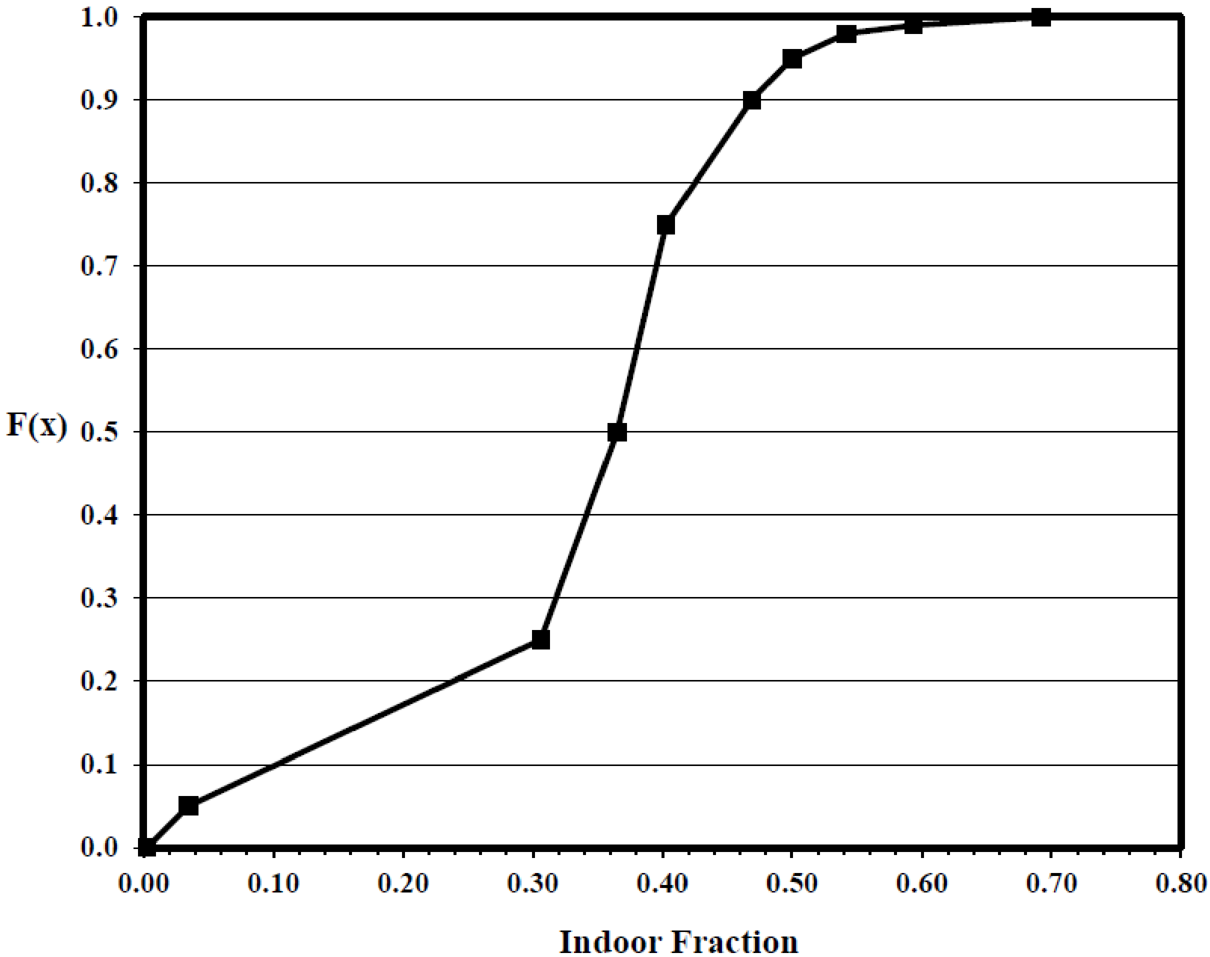

Figure C-41 Indoor Fraction Cumulative Distribution Function for RESRAD-BUILD

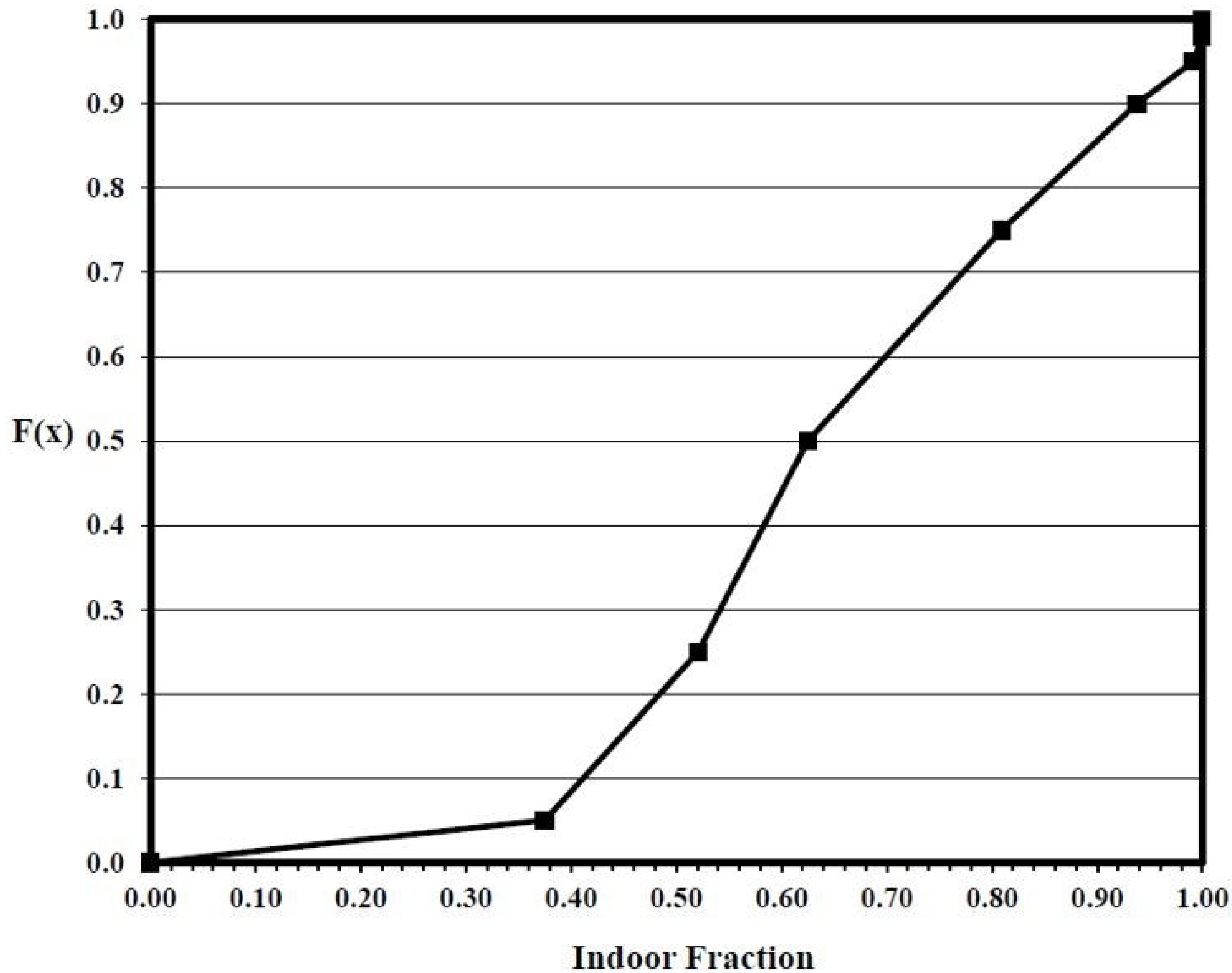

Figure C-42 Indoor Fraction Cumulative Distribution Function for RESRAD-ONSITE and RESRAD-OFFSITE Codes

Table C-66 Statistics for Fraction of Time Spent Indoors at Work

Category	Population Group	N[a]	Min	Max	5	25	50	75	90	95	98	99
Fraction per Day Indoors at a Plant/Factory/Warehouse												
All		383	0.001	0.692	0.021	0.243	0.354	0.394	0.465	0.49	0.535	0.594
Gender	Male	271	0.001	0.692	0.021	0.253	0.358	0.399	0.469	0.5	0.542	0.604
Gender	Female	112	0.003	0.569	0.01	0.218	0.354	0.385	0.417	0.469	0.49	0.5
Age (yr.)	18–64	353	0.003	0.692	0.021	0.267	0.361	0.396	0.465	0.49	0.535	0.594
Employment	Full-Time	333	0.003	0.692	0.035	0.306	0.365	0.403	0.469	0.5	0.542	0.594
Fraction per Day Spent Indoors at Work (unspecified)												
All		137	0.003	0.68	0.01	0.125	0.306	0.385	0.46	0.563	0.653	0.667
Gender	Male	96	0.007	0.68	0.014	0.17	0.328	0.415	0.531	0.583	0.667	0.68
Gender	Female	41	0.003	0.542	0.01	0.063	0.194	0.344	0.382	0.41	0.542	0.542
Age (yr.)	18–64	121	0.003	0.68	0.01	0.167	0.313	0.389	0.458	0.551	0.59	0.667
Employment	Full-Time	97	0.007	0.68	0.01	0.208	0.333	0.406	0.479	0.566	0.667	0.68

[a] Number of subjects in the survey.
Source: Derived from cumulative minutes per day spent indoors listed in EPA (1997).

Table C-67 Statistics for Fraction of Time Spent Indoors in a Residence

Census Region	Age Group	N[a]	Mean	Minimum	Percent							Maximum
					5	25	50	75	90	95	99	
Whole U.S.	All	9343	0.70	0.01	0.40	0.55	0.68	0.86	0.97	1.00	1.00	1.00
Whole U.S.	Male	4269	0.68	0.01	0.38	0.52	0.63	0.81	0.94	0.99	1.00	1.00
Whole U.S.	Female	5070	0.72	0.021	0.43	0.58	0.73	0.89	0.99	1.00	1.00	1.00
Whole U.S.	<1 year	187	0.70	0.18	0.39	0.55	0.66	0.85	1.00	1.00	1.00	1.00
Whole U.S.	1–4 years	498	0.84	0.19	0.55	0.74	0.88	0.98	1.00	1.00	1.00	1.00
Whole U.S.	5–11 years	700	0.70	0.13	0.48	0.59	0.68	0.81	0.93	0.98	1.00	1.00
Whole U.S.	12–17 years	588	0.67	0.07	0.41	0.56	0.66	0.80	0.91	0.98	1.00	1.00
Whole U.S.	18–64 years	6022	0.66	0.01	0.38	0.52	0.63	0.81	0.94	0.99	1.00	1.00
Whole U.S.	>64 years	1348	0.82	0.04	0.53	0.72	0.84	0.95	1.00	1.00	1.00	1.00
Northeast	All	2068	0.70	0.02	0.40	0.55	0.68	0.86	0.98	1.00	1.00	1.00
Midwest	All	2087	0.70	0.01	0.39	0.55	0.69	0.87	0.97	1.00	1.00	1.00
South	All	3230	0.69	0.01	0.41	0.56	0.67	0.85	0.97	1.00	1.00	1.00
West	All	1958	0.70	0.02	0.40	0.56	0.69	0.85	0.97	1.00	1.00	1.00

[a] Number of subjects in the survey.
Source: Calculated from minutes per day spent indoors listed in Table 16-16, EPA (2011)

C.5.10 Outdoor Fraction

Applicable Code: RESRAD-ONSITE, RESRAD-OFFSITE

Description: The outdoor fraction is the fraction of time an individual spends outside the residence (RESRAD-ONSITE, RESRAD-OFFSITE) or outside in the agricultural fields (RESRAD-OFFSITE).

Units: no units

Probabilistic Input:

Distribution: continuous linear

Defining Values for Distribution: See Table C-68 for the input values.

Discussion: In RESRAD-ONSITE and RESRAD-OFFSITE, the outdoor fraction is used in the exposure calculations to calculate the amount of time spent outdoors at the residence or dwelling location. Actual exposure times at each location are estimated by multiplying the exposure duration by the outdoor fraction at the receptor location. In RESRAD-OFFSITE, an additional time fraction spent outdoors in farmed areas is used.

For RESRAD-ONSITE, the outdoor fraction is the fraction of time spent outside the residence where the receptor is exposed to external radiation from contaminated soil and resuspended contamination. This situation translates into the amount of time spent outdoors at a residence when evaluating the residential farmer scenario. The EPA's Exposure Factors Handbooks (EPA, 1997, 2011) contain a comprehensive review of human activity patterns, including time spent at home in the yard. That review extracts data for time spent at home from the most complete and current study on activity patterns (Tsang and Klepeis, 1996). Table C-68 summarizes a number of distributions, including distributions for time spent outdoors at home in the yard or other areas outside the house. The distribution chosen to represent the average members of the critical group (adult males) in the residential farmer scenario was that for the age group of 18–64 years. This distribution is almost identical to that for the male population group and close to those for all subjects and the female population group. Figure C-43 presents the cumulative distribution function for the outdoor fraction parameter in RESRAD- ONSITE. This distribution function is also appropriate for the fraction of time spent outdoors at the offsite dwelling site in RESRAD-OFFSITE.

Table C-68 Cumulative Distribution Functions for the Outdoor Fraction

Cumulative Probability	Outdoor Fraction	
	Residence/Dwelling	Each Farmed Area
0.00	0.000174	0.000868
0.05	0.00694	0.00347
0.25	0.0278	0.0139
0.5	0.0625	0.0399
0.75	0.125	0.0868
0.9	0.222	0.11
0.95	0.292	0.127
0.98	0.396	0.162
0.99	0.458	0.166
1.00	0.896	0.166

There are four farmed areas in RESRAD-OFFSITE code. The sum of the fraction of the time spent outdoors in the four farmed areas in RESRAD-OFFSITE can be approximated by the amount of time spent outdoors on a farm (EPA, 1997). Because RESRAD-OFFSITE models four different fields, the fraction of time spent in each field is assumed to be one-quarter the value of the total fraction of time spent farming. The distribution function values for this fraction are given in Table C-68. Again, the values used are for the age group of 18–64 years, but these values are similar to those for all receptors, or for male or female receptors, as shown in

Table C-69. The cumulative distribution function for the fraction of time spent outdoors in a farm field is shown in Figure C-44. For a true site-specific analysis, the fraction of time spent in each of the farm fields must be adjusted to account for the actual number of fields affected as well as the activities to be performed in each field.

For other scenarios using RESRAD-ONSITE or RESRAD-OFFSITE that involve the fraction of time spent outdoors, EPA (1997, 2011) also contains information on the time spent outdoors at work (other than on farms). This distribution is shown in Table C-69. Data Collection Handbook (Yu et al. 2015) Table 9.6.1 provides distribution for time spent outdoor for recreational activities.

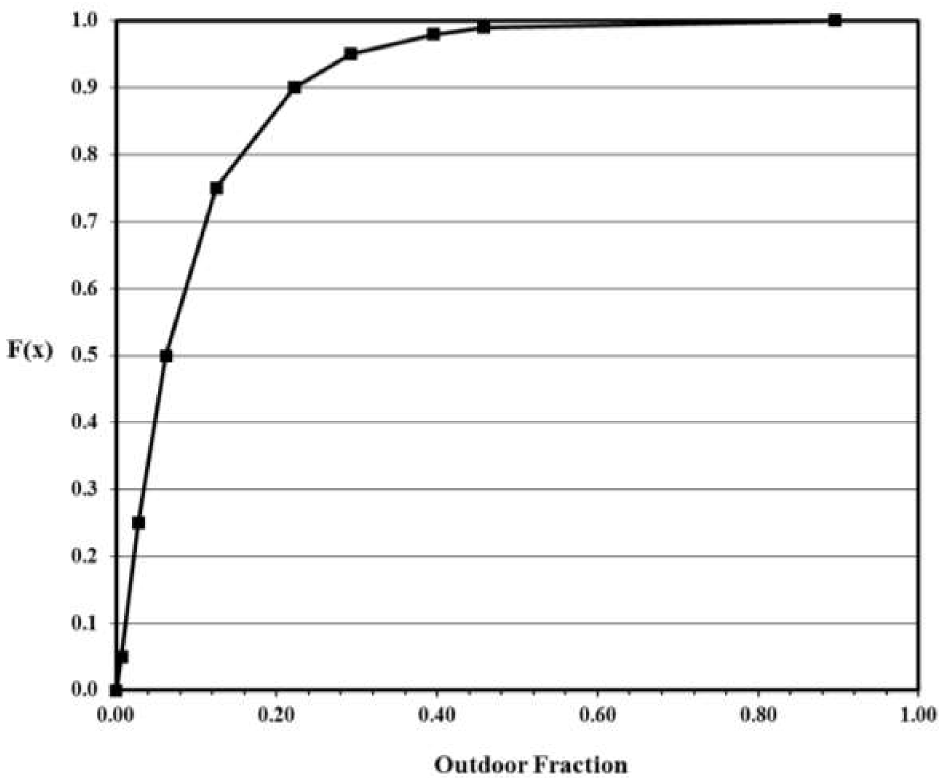

Figure C-43 Outdoor Time Fraction Cumulative Distribution Function for the Residence (RESRAD-ONSITE) or Dwelling (RESRAD-OFFSITE)

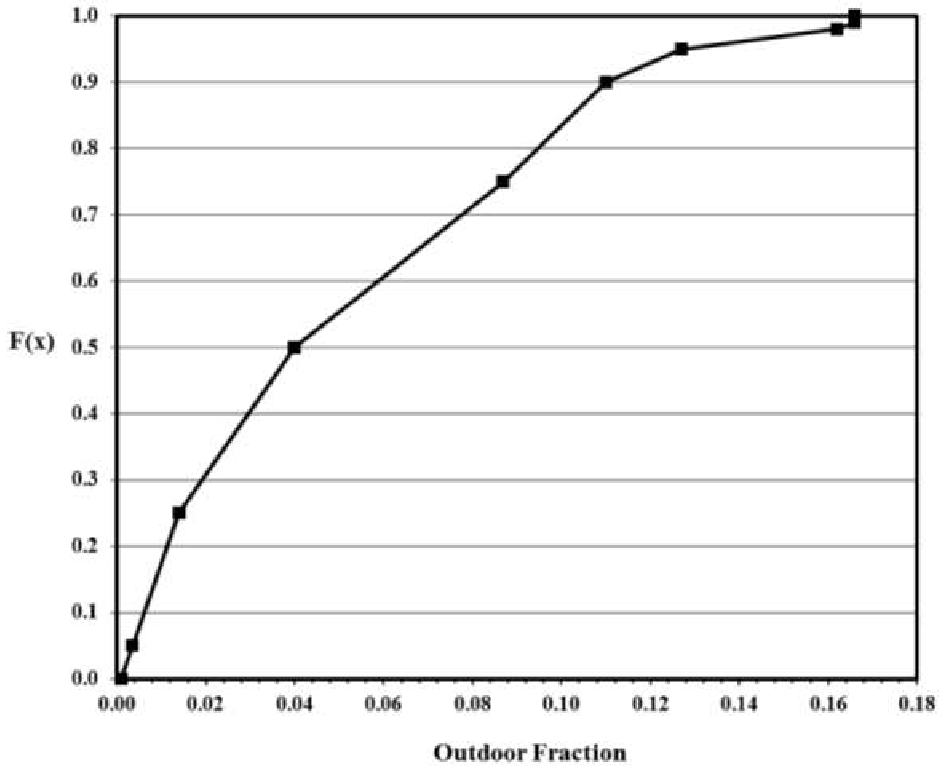

Figure C-44 Outdoor Time Fraction Cumulative Distribution Function for the Time Spent in a Farm Field

Table C-69 Statistics for Fraction of Time Spent Outdoors per Day

Category	Population Group	N[a]	Min.	Max.	Percentiles 5	25	50	75	90	95	98	99
Fraction per Day Outdoors at Home or Other Areas Outside the House												
All		2308	0.001	0.896	0.00694	0.0278	0.0625	0.125	0.222	0.292	0.396	0.458
Gender	Male	1198	0.001	0.896	0.00694	0.0417	0.0833	0.138	0.250	0.347	0.435	0.507
Gender	Female	1107	0.001	0.740	0.00347	0.0208	0.0521	0.104	0.198	0.250	0.313	0.389
Age (yr.)	18–64	1301	0.001	0.750	0.00347	0.0208	0.0625	0.125	0.229	0.302	0.396	0.497
Fraction per Day Outdoors on a Farm Field												
All		128	0.000	0.166	0.003	0.013	0.031	0.074	0.104	0.127	0.148	0.162
Gender	Male	86	0.001	0.166	0.005	0.016	0.040	0.087	0.115	0.135	0.162	0.166
Gender	Female	42	0.001	0.104	0.003	0.009	0.018	0.036	0.046	0.084	0.104	0.104
Age (yr.)	18–64	91	0.001	0.166	0.003	0.014	0.040	0.087	0.110	0.135	0.162	0.166
Fraction per Day Spent Outdoors at Work												
All		4891	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.021	0.035
Gender	Male	2463	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.011	0.029	0.042
Gender	Female	2428	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.008
Age (yr.)	18–64	4621	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.021	0.035

[a] Number of subjects in the survey.
Source: Derived from cumulative minutes per day spent outdoors listed in EPA (1997).

C.6 Crops and Livestock

C.6.1 Depth of Roots

Applicable Code: RESRAD-ONSITE, RESRAD-OFFSITE

Description: This parameter represents the average root depth of various plant types grown in the contaminated zone. For RESRAD-OFFSITE, the plant types consumed by humans are divided in two categories: leafy vegetables and fruit, grain, and non-leafy vegetables. The plant types consumed by livestock are also divided in two categories: pasture and silage, and grain.

Units: meters (m)

Probabilistic Input:

Distribution: uniform

Defining Values for Distribution: See Table C-70.

Discussion: Root depth varies by plant type. For some plants (e.g., cabbage, spinach, lettuce, broccoli, and others) root depth does not extend below about 0.9 m. For other plants (e.g., fruit trees) the roots may extend 2 m below the surface. Tap roots for some crops (e.g., alfalfa) can extend to 3.6 m. Most of the plant roots from which nutrients are obtained, however, usually extend less than 1 m below the surface.

For onsite exposure, the root depth is used to calculate the cover and depth factor for the plant, meat, and milk exposure pathways, because edible plants become contaminated through root uptake of radionuclides. Uptake of radionuclides from plant roots is assumed possible only when the roots extend to the contaminated zone, and it is limited to the fraction of roots that have direct contact with contaminated soil.

Table C-70 Uniform Distribution Input for Depth of Roots

Field Type	Minimum	Maximum
RESRAD-OFFSITE		
Pasture and silage	0.3	3.6
Grain	0.5	2.4
Fruit, grain, and non-leafy vegetables	0.3	2.4
Leafy vegetables	0.3	0.9
RESRAD-ONSITE		
Contaminated area	0.3	3.6

Each crop has characteristic rooting habits that it will tend to follow if the soil is deep, uniform, and equally moist throughout. The depth of rooting increases during the growing period. Crops that mature in 2 months usually penetrate only 0.6–0.9 m, and crops that require 6 months to mature may penetrate 1.8–3.0 m or more.

When the upper portion of the soil is kept moist, plants will obtain most of their moisture supply from near the surface. As the moisture content of the upper layers decreases, the plants draw more water from the lower layers, which encourages more root development in the lower levels. Fewer roots exist in the lower portion of the root zone because of the inability of the root system to extract enough moisture from the lower levels. Generally, the average root-zone depths are reached by the time the foliage of the plant has reached its maximum size. Root-zone depths are limited to the soil depth above the water table.

Table C-71 lists rooting depths for a variety of forages that can be used for livestock consumption. Growing conditions (e.g., amount of rainfall or temperature) vary annually and geographically across the United States, and the type of forage consumed by livestock is uncertain. Therefore, for forages, a uniform distribution with a minimum of 0.3 m and a maximum of 3.6 m (as shown in Figure C-45) is suggested for use in RESRAD-OFFSITE. If specific conditions are known, values from Table C-46 for a specific forage type may be used.

Table C-72 lists rooting depths for a variety of grains that can be used for livestock consumption. In general, the grain crops grown during the spring season have less rooting depths compared with the crops grown during the winter season. The criteria cited for forage crops also apply to grain crops. Therefore, for grain, a uniform distribution with a minimum of 0.5 m and a maximum of 2.4 m (as shown in Figure C-45) is suggested for use in RESRAD-OFFSITE. If specific conditions are known, values from Table C-72 for a specific grain type may be used.

Table C-73 lists rooting depths for fruits and nuts, grains, and non-leafy vegetables that can be consumed by humans. In general, the grain crops grown during the spring season have less rooting depths compared with the crops grown during the winter season. For fruit, grain, and non-leafy vegetables, a uniform distribution with a minimum of 0.3 m and a maximum of 2.4 m (as shown in Figure C-47) is suggested for use in RESRAD-OFFSITE. If specific conditions are known, values from Table C-73 for a specific plant type may be used.

Table C-74 lists rooting depths for leafy vegetables that can be consumed by humans. For leafy vegetables, a uniform distribution with a minimum of 0.3 m and a maximum of 0.9 m (as shown in Figure C-48) is suggested for use in RESRAD-OFFSITE.

If specific conditions are known, values from Table C-74 for a specific leafy vegetable may be used.

Minimum and maximum values of 0.3 and 3.6 m, respectively, for the root depth are suggested as input to RESRAD-ONSITE, which does not distinguish among the plant types. These values bound those presented in previous tables. However, site-specific minimum and maximum root depths should be used, based on the plant types present, and these may be obtained from Table C-71 through Table C-74. Figure C-49 presents the uniform probability density function for root depth for RESRAD-ONSITE.

Table C-71 Root Depth of Forage from Different Sources

Forage Types	Depth (m)	Curwen and Massie (1994)	Weaver (1926)	Georgeson and Payne (1897)	Canadell et al. (1996)	Allen et al. (1998)
Alfalfa	0.6–3.6	0.6–1.2	3–3.6	1.5–1.8		1.0–3.0
Bermuda grass	1.0–1.5					1.0–1.5
Bluegrass	0.3–2.1		1.5–2.1	0.3–1.1		
Broome grass	1.1–2.0		1.7–2.0		1.1	
Canary grass	0.6–1.5			0.6–1.5		
Clover, ladino	1.5–2.4		1.5–2.4			
Clover, red	0.6–2.4	0.6	1.5–2.4	1.5		0.6–0.9
Fescue	0.6–1.2		0.6–1.2			
Orchard grass	0.9–1.3		0.9–1.3			
Rye grass	0.6–0.9		0.6–0.9			0.6–1.0
Trefoil	0.6–1.2	0.6–1.2				
Timothy	0.4–0.9		0.4–0.9			
Buffalo grass	0.6–1.9		0.6–0.9	0.9	1.9	
Pasture grasses	0.6–1.5	0.6–1.2				0.5–1.5
Big bluestem	1.5–2.8		1.5–2.7		1.5–2.8	
Little bluestem	0.9–1.8		0.9–1.7		1.5–1.8	

Sources: Modified from Weaver (1926), Georgeson and Payne (1897), Canadell et al. (1996), Curwen and Massie (1994), Allen et al. (1998).

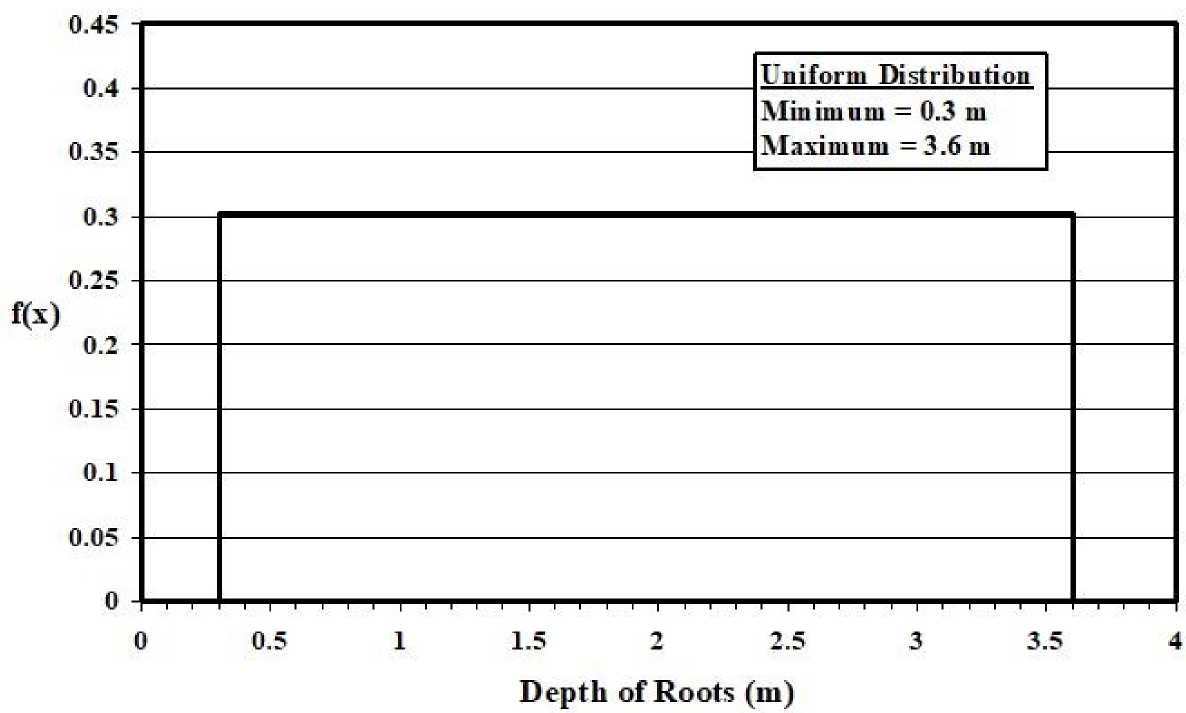

Figure C-45 Root Depth Probability Density Function for Pasture and Silage

Table C-72 Root Depth of Grains from Different Sources

Grain Plants	Range Root Depth (m)	Allen et al. (1998)	Weaver and Brunner (1927)	Curwen and Massie (1994)	Weaver (1926)
Barley	1.0–2.0	1.0–1.5			1.4–2.0
Corn	1.0–2.4	1.0–1.7	1.5–2.4	0.6–1.2	1.5–1.8
Millet	1.0–2.0	1.0–2.0			
Oat	1.0–1.5	1.0–1.5			1.2–1.5
Rice	0.5–1.0	0.5–1.0			
Sorghum	1.0–2.0	1.0–2.0			1.4–1.8
Spring wheat	1.0–1.5	1.0–1.5		0.6	
Winter wheat	1.5–2.1	1.5–1.8			1.5–2.1

Sources: Allen et al. (1998), Weaver and Brunner (1927), Curwen and Massie (1994), Weaver (1926).

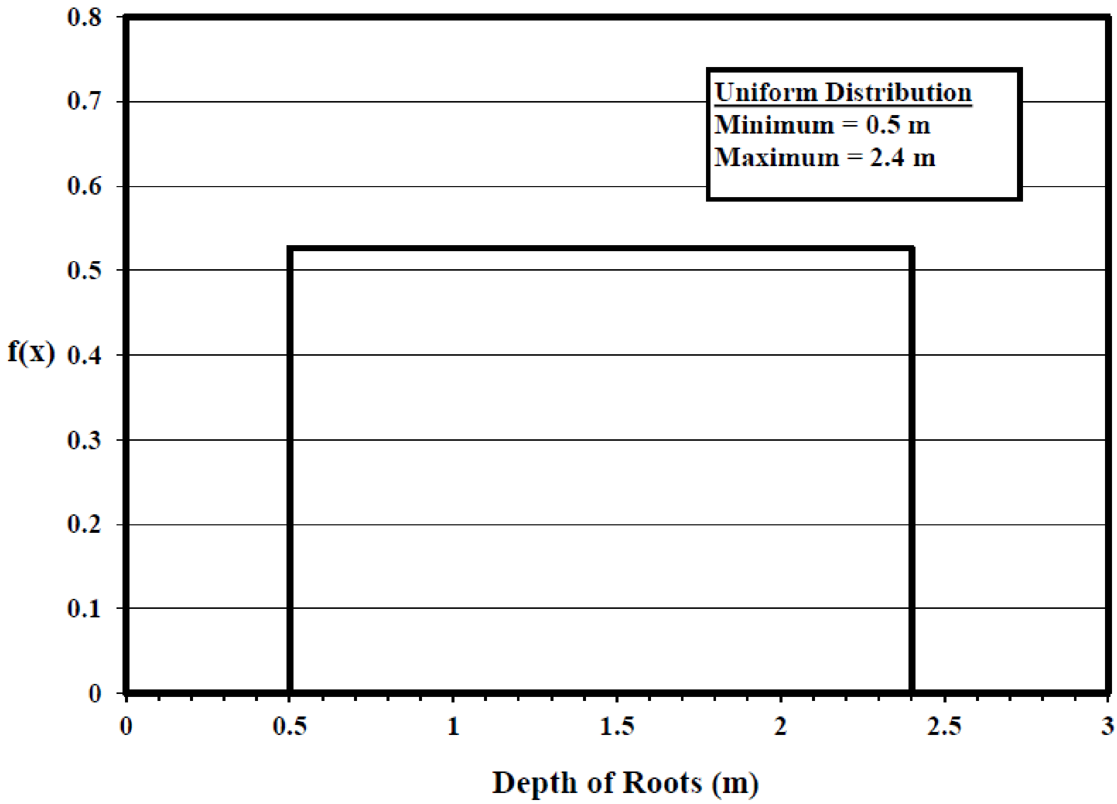

Figure C-46 Root Depth Probability Density Function for Grains

Table C-73 Root Depth of Fruits and Nuts, Grains, and Non-Leafy Vegetables from Different Sources

Plant type	Range Root Depth (m)	Allen et al. (1998)	Weaver and Brunner (1927)	Kemble and Sanders (2000)	Evans et al. (1996)	Curwen and Massie (1994)	Weaver (1926)
Fruit and nuts							
Almond, apple, apricot, cherry, grape, peach, and pear	1.0–2.0	1.0–2.0					
Avocado	0.5–1.0	0.5–1.0					
Banana	0.5–0.9	0.5–0.9					
Berries	0.6–1.2	0.6–1.2				0.6–1.2	
Cantaloupe	0.3–1.5	0.9–1.5	1.1	0.3–0.6			
Citrus fruits	1.2–1.5	1.2–1.5					
Kiwi	0.7–1.3	0.7–1.3					
Olive	1.2–1.7	1.2–1.7					
Pineapple	0.3–0.6	0.3–0.6					
Pistachio	1.0–1.5	1.0–1.5					
Strawberry	0.2–0.6	0.2–0.3	0.3–0.6		0.3	0.3	
Sweet melon, watermelon	0.8–1.5	0.8–1.5	1.1	>0.6		0.6–1.2	
Grain							
Barley	1.0–2.0	1.0–1.5					1.4–2.0
Corn	1.0–2.4	1.0–1.7	1.5–2.4			0.6–1.2	1.5–1.8
Millet	1.0–2.0	1.0–2.0					
Oat	1.0–1.5	1.0–1.5					1.2–1.5
Rice	0.5–1.0	0.5–1.0					
Sorghum	1.0–2.0	1.0–2.0					1.4–1.8
Spring wheat	1.0–1.5	1.0–1.5				0.6	
Winter wheat	1.5–2.1	1.5–1.8					1.5–2.1
Non-Leafy vegetables							
Artichoke	0.6–0.9	0.6–0.9					
Asparagus	1.2–3.0	1.2–1.8	1.5–3.0	>0.6			
Carrot	0.3–2.0	0.5–1.0	0.6–2.0	0.3–0.6	0.5		
Chick pea	0.3–1.0	0.6–1.0	0.6–1.0	0.3–0.6	0.5	0.6	
Cucumber	0.3–1.2	0.7–1.2	1.1	0.3–0.6			
Eggplant	0.3–2.0	0.7–1.2	1.2–2.0	0.3–0.6			
Green bean	0.5–0.7	0.5–0.7		0.5–0.6	0.5		
Lima bean	0.6–1.2	0.8–1.2	0.9–1.2	>0.6		0.6	
Okra	0.5–1.2		0.5–1.2	>0.6			
Onion	0.3–1.0	0.3–0.6	0.5–1.0	0.3–0.5	0.3	0.5	
Potato	0.3–0.9	0.4–0.6		0.3–0.5	0.5	0.5	0.6–0.9
Pumpkin	0.6–1.8	1.0–1.5	1.8	>0.6		0.6–1.2	
Radish	0.3–0.9	0.3–0.5	0.6–0.9				
Squash, zucchini	0.3–1.8	0.6–1.0	1.8	0.3–0.6		0.6–1.2	
Sugar beet	0.5–2.0	0.7–1.2	1.2–2.0	0.5–0.6	0.5	0.5	1.5–1.8
Sweet pepper	0.3–1.2	0.5–1.0	0.9–1.2	0.3–0.6	0.3	0.6	
Sweet potato	0.6–1.5	1.0–1.5	1.2	>0.6			
Tomatoes	0.6–1.7	0.7–1.5	1.0–1.7	>0.6			
Turnip	0.5–1.5	0.5–1.0	1.5				

Sources: Allen et al. (1998), Weaver and Brunner (1927), Kemble and Sanders (2000), Evans et al. (1996), Curwen and Massie (1994), Weaver (1926).

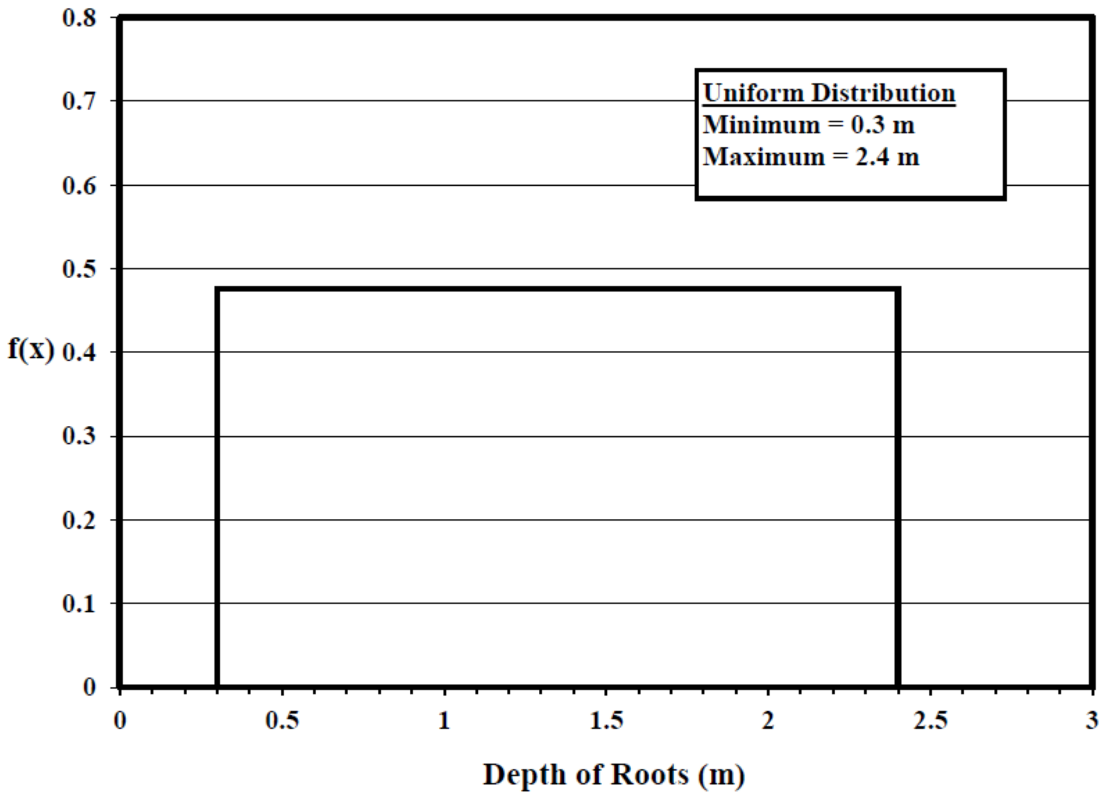

Figure C-47 Root Depth Probability Density Function for Fruits, Grains, and Non-Leafy Vegetables

Table C-74 Root Depth of Leafy Vegetables from Different Sources

Leafy Vegetables	Root Depth (m)	Curwen and Massie (1994)	Allen et al. (1998)	Weaver and Brunner (1927)	Kemble and Sanders (2000)	Evans et al. (1996)
Spinach	0.3–0.5		0.3–0.5	0.3	0.3–0.5	0.3–0.5
Lettuce	0.3–0.9	0.5	0.3–0.5		0.6–0.9	0.3–0.5
Broccoli	0.3–0.6		0.4–0.6		0.3–0.5	0.3–0.5
Celery	0.3–0.5		0.3–0.5		0.3–0.5	
Cabbage	0.3–0.9		0.5–0.8	0.9	0.3–0.5	0.3–0.5
Cauliflower	0.3–0.9		0.4–0.7	0.9	0.3–0.5	0.3–0.5
Brussel sprout	0.3–0.6		0.4–0.6		0.3–0.5	
Mint	0.4–0.8		0.4–0.8			
Collard	0.3–0.5				0.3–0.5	
Mustard	0.3–0.6				0.5–0.6	0.3–0.5

Source: Curwen and Massie (1994), Allen et al. (1998), Weaver and Brunner (1927), Kevin and Sanders (2000), Evans et al. (1996).

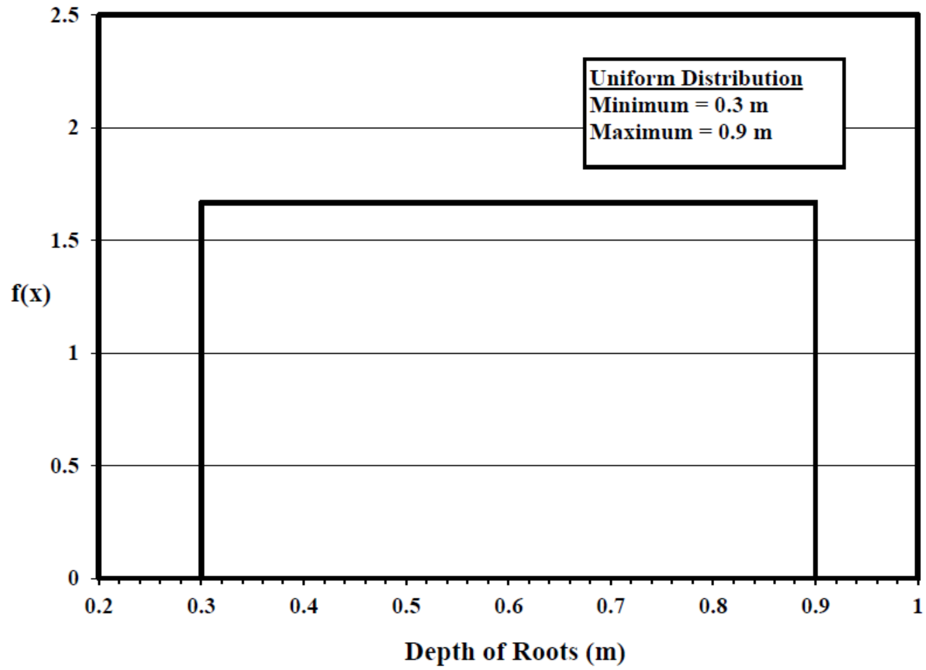

Figure C-48 Root Depth Probability Density Function for Leafy Vegetables

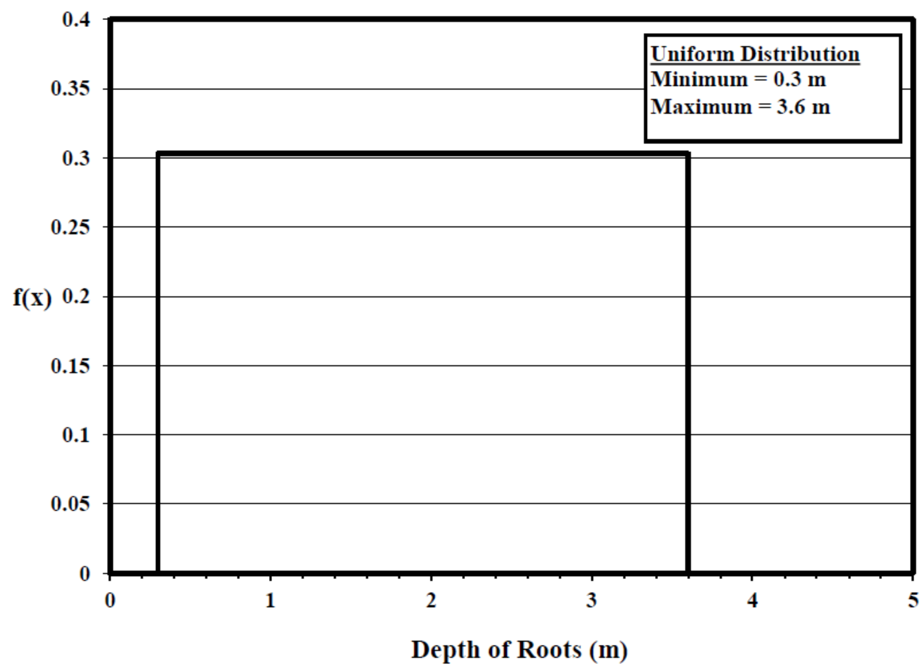

Figure C-49 Root Depth Probability Density Function for RESRAD-ONSITE

C.6.2 Duration of the Growing Season

Applicable Code: RESRAD-OFFSITE

Description: The growing season is the period of time during which a plant is exposed to contamination by foliar deposition and root uptake.

Units: days

Probabilistic Input:

Distribution: triangular

Defining Values for Distribution: See Table C-75 Triangular Distribution Values for Duration of the Growing Season (Days).

Discussion: The growing period, as defined by the National Council on Radiation Protection and Measurements (NCRP), is the time of aboveground exposure of a crop to contamination during the growing season (NCRP, 1984). The period varies with plant type and with the growing season for a particular region (Hoffman et al., 1982).

Many references use a growing period of 30 days for pasture grasses and 60 days for produce (NRC, 1977; NCRP, 1984; Whelan et al., 1987; DOE, 1995). 30 days for pasture grasses represents animal grazing habits (Whelan et al., 1987), and 60 days for produce represents the approximate growing time for vegetable crops.

The FAO of the United Nations studies different food crops (Allen et al., 1998) and provides information about the duration of the different stages of plant growth for different crops. The plant growth is divided into four stages: the initial stage, the crop development stage, the midseason stage, and the late season stage. The initial stage runs from the planting date to approximately 10 percent ground cover. For perennial crops, the planting date is replaced by the “green-up” date, which refers to the time when the initiation of new leaves occurs. The crop development stage runs from 10 percent ground cover to effective full cover. The midseason stage runs from effective full cover to the start of maturity. The late season stage runs from the start of maturity to harvest or full senescence. The data are provided for different vegetables, fiber crops, oil crops, grains, forages, and fruits.

Many species of grasses (e.g., orchard grass, canary grass, timothy, brome grass, rye grass, and fescue) and legumes (e.g., red clover, alfalfa, and trefoil) are used as forages. Multiple clippings of forages are possible in a growing season (Owensby and Anderson, 1969; Baker, 2002; Baker, 2003; Majewski, 2004). Table C-76 Time (Days) Taken by Different Forages during Four Stages of Growth lists the data extracted from Allen et al. (1998) for different forages. In general, it takes longer to grow first cuttings compared with other cuttings. For forages, it is expected that foliar deposition during the time between initial crop development and the start of maturity (i.e., when the crop has emerged from the ground and is ready to be grazed by animals) could contribute to the dose of contamination that is ingested when the forage is consumed. Therefore, the time taken from crop development to the start of maturity is used to develop a distribution for forages. The proposed growing period for forages (Figure C-50) is represented by a triangular distribution with minimum = 20 days, most likely = 30 days, and maximum = 55 days.

Table C-75 Triangular Distribution Values for Duration of the Growing Season (Days)

Probabilistic Input	Field Type			
	Forage	Grain	Fruit, Grain, and Non-Leafy Vegetables	Leafy Vegetables
Minimum	20	60	30	40
Most likely	30	120	105	75
Maximum	55	210	320	180

Table C-76 Time (Days) Taken by Different Forages during Four Stages of Growth

Forage	Time Taken During Different Stages of Plant Growth (in days)				
	Initial	Crop Development	Start of Maturity	Harvest	Total (from crop development to start of maturity)
Alfalfa, first cutting	10	20–30	20-25	10	40-55
Alfalfa, other cuttings	5	10-20	10	5-10	20-30
Bermuda for hay (multiple cuttings)	10	15	75	35	30
Sudan, first cutting	25	25	15	10	40
Sudan, other cuttings	3	15	12	7	27

The usual planting and harvesting dates for U.S. field crops are provided in Agricultural Handbook Number 628 (USDA, 1997). The information on the duration of the growing season for grains is extracted from this handbook. Table C-77 Growing Period (Days) for Different Grain Crops in the United States summarizes the average, minimum, and maximum growing period for different field crops in the United States. It also lists the number of states where the crop is grown, the total harvested acres, the largest producing state, and the most likely uses of the crop. In some cases, multiple crops may be harvested during the growing season. Corn and winter wheat are harvested in most states in the United States. The stored grains most commonly used as livestock feed are barley, oats, corn, and sorghum. The minimum time required to grow these crops is 70 days. The maximum time required for the spring crop is 190 days.

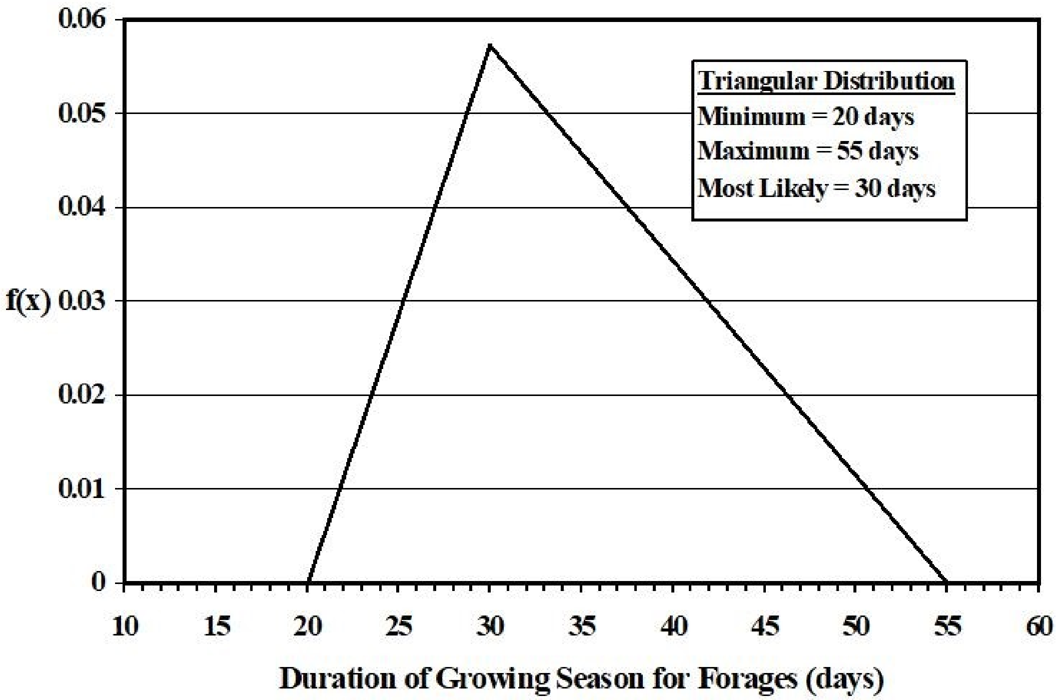

Figure C-50 Probability Density Function for Forages for Duration of the Growing Season

Table C-77 Growing Period (Days) for Different Grain Crops in the United States

Grains	Average	Minimum	Maximum	Number of States	Harvested Acres	Largest Producing States
Barley (spring)	1.1E+02	7.0E+01	1.8E+02	1.7E+01	6.4E+06	North Dakota
Barley (fall)	2.4E+02	1.1E+02	3.1E+02	1.4E+01	3.5E+02	Virginia and Pennsylvania
Wheat (spring)	1.2E+02	1.0E+02	1.5E+02	1.2E+01	2.0E+07	North Dakota
Wheat (winter)	2.7E+02	1.5E+02	3.4E+02	4.2E+01	4.0E+07	Kansas
Soybean	1.4E+02	1.2E+02	1.7E+02	2.9E+01	6.3E+07	Iowa and Illinois
Sorghum	1.4E+02	9.4E+01	1.7E+02	1.8E+01	1.2E+07	Kansas
Rice	1.4E+02	1.2E+02	1.5E+02	6.0E+00	2.8E+06	Arkansas
Oat (fall)	2.3E+02	1.7E+02	2.7E+02	7.0E+00	2.5E+05	Texas
Oat (spring)	1.1E+02	8.4E+01	1.8E+02	2.4E+01	2.4E+06	North Dakota
Corn for grain	1.6E+02	1.3E+02	1.9E+02	C.6.2E+01	7.3E+07	Iowa and Illinois

Table C-78 lists the data extracted from Allen et al. (1998) for different grains. In general, it takes longer to grow fall or winter crops compared with a spring crop. For grain, it is expected that foliar deposition during the time between initial crop development and the time of harvest could contribute to the dose of contamination that is ingested when the grain is consumed. Therefore, the total time taken from crop development to the start of harvest is used to develop a distribution for grains. The proposed growing period for grains (Figure C-51) is represented by a triangular distribution with minimum = 60 days, most likely = 120 days, and maximum = 210 days.

Table C-78 Time (Days) Taken by Different Grains during Four Stages of Growth

Grains	Initial	Crop Development	Start of Maturity	Harvest	Total (from crop development to harvest)
Barley/oats/spring wheat	15-40	25-60	40-60	20-40	90-160
Winter wheat	20-160	60-140	40-75	25-30	175-210
Small grains	20-25	30-35	60-65	40	130-140
Corn grain	20-30	35-50	40-60	30-50	105-150
Sweet corn	20-30	20-40	25-70	10-103	60-163
Millet	15-20	25-30	40-55	25-35	90-120
Sorghum	20	35	40-45	30	105-110
Rice	30	30	60-80	30-40	120-150

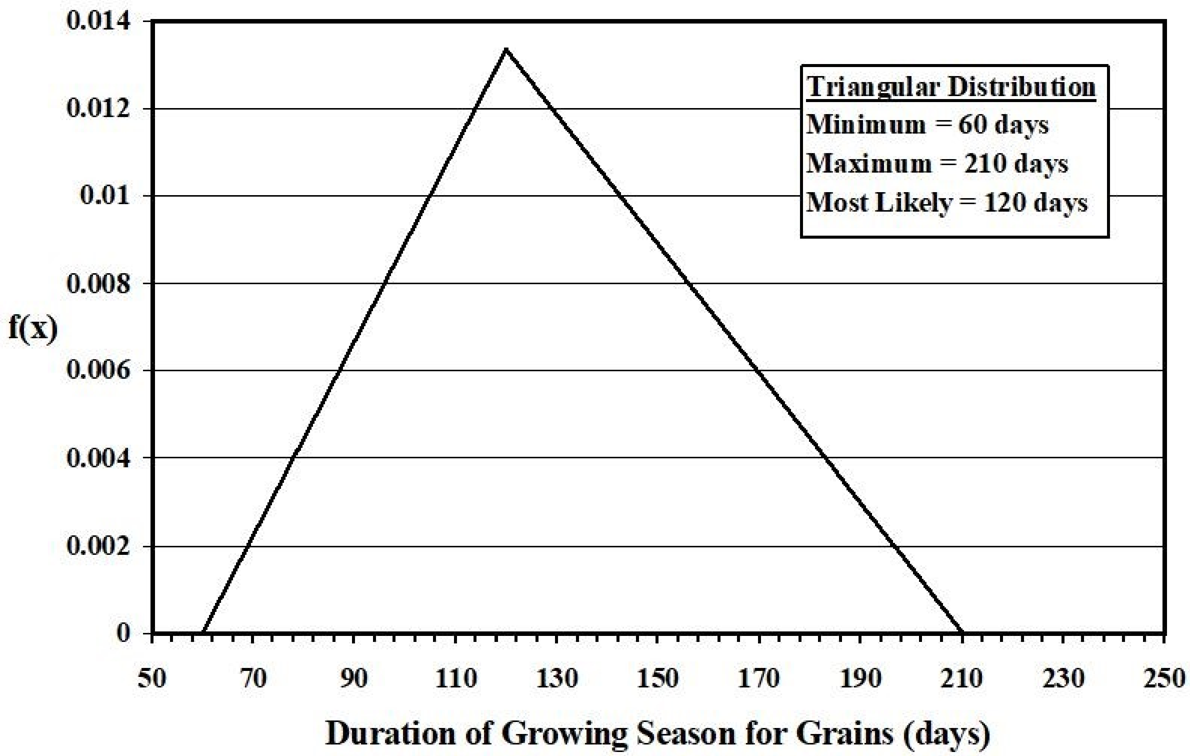

Figure C-51 Probability Density Function for Grains for the Duration of the Growing Season

Table C-79 lists the data extracted from Allen et al. (1998) for different fruits, nuts, grains, and non-leafy vegetables. For these plant food types, it is expected that foliar deposition during the time between initial crop development, and the time of harvest could contribute to the dose of contamination that is ingested when the food is consumed. Therefore, the total time taken from crop development to the start of harvest is used to develop a distribution for fruits, grains, and non-leafy vegetables. The proposed growing period for fruits, grains, and non-leafy vegetables (Figure C-52) is represented by a triangular distribution with minimum = 30 days, most likely= 105 days, and maximum = 320 days.

Table C-79 Time (Days) Taken by Different Fruits and Nuts, Grains, and Non-Leafy Vegetables during Four Stages of Growth

	Initial	Crop Development	Start of Maturity	Harvest	Total (from crop development to harvest)
Fruits and nuts					
Banana	120	60-90	120-180	5-60	245-270
Cantaloupe	10-30	45-60	25-40	10-25	90-110
Citrus	60	90	120	95	305
Grape	20-30	40-60	40-120	20-80	160-220
Olive	30	90	60	90	240
Pistachio	20	60	30	40	130
Sweet melon	15-30	30-45	40-65	15-30	95-130
Walnut	20	10	130	30	170
Watermelon	10-20	20-30	20-30	30	70-90
Grains					
Barley/oats/wheat	15-40	25-60	40-65	20-40	90-160
Corn (grain)	20-30	35-50	40-60	30-50	105-150
Grains (small)	20-25	30-35	60-65	40	130-140
Millet	15-20	25-30	40-55	25-35	90-120
Rice	30	30	60-80	30-40	120-150
Sorghum	20	35	40-45	30	105-110
Sweet corn	20-30	20-40	25-70	10-103	60-163
Winter wheat	20-160	60-140	40-75	25-30	160-210
Non-Leafy vegetables					
Artichoke	20-40	25-40	250	30	305-320
Asparagus	50-90	30	100-200	45-50	180-275
Bean (dry)	15-25	25-30	30-40	20	75-90
Bean (green)	15-20	25-30	25-30	10	60-70
Beet	15-25	25-30	20-25	10	55-65
Bell pepper	25-30	35-40	40-110	20-30	95-180
Broad bean (dry)	90	45	40	60	145
Broad bean (green)	90	45	40	0	85
Carrot	20-30	30-50	30-90	20-30	80-170
Cassava	20-150	40	90-110	60	190-210
Cucumber	20-25	30-35	40-50	15-20	85-105
Eggplant	30	40-45	40	20-25	100-110
Faba bean	15-20	25-30	35	15	75-80

Table C-79 Time (Days) Taken by Different Fruits and Nuts, Grains, and Non-Leafy Vegetables during Four Stages of Growth (cont.)

	Initial	Crop Development	Start of Maturity	Harvest	Total (from crop development to harvest)
Non-Leafy vegetables (cont.)					
Green gram, cowpea	20	30	30	20	80
Groundnut	25-35	35-45	35-45	25-35	105
Hops	25	40	80	10	130
Lentil	20-25	30-35	60-70	40	130-145
Onion	15-20	25-35	70-110	40-45	135-190
Pea	15-35	25-30	30-35	15-20	75-80
Potato	25-45	30-35	30-70	20-30	90-120
Pumpkin	20-25	30-35	30-35	20-25	80-95
Radish	5-10	10	15	5	30
Soybean	15-20	15-35	40-75	15-30	70-130
Squash, zucchini	20-25	30-35	25	15	70-75
Sugar beet	25-50	30-75	50-100	10-65	130-230
Sweet potato	15-20	30	50-60	30-40	110-130
Tomato	25-35	40-45	45-70	25-30	105-145

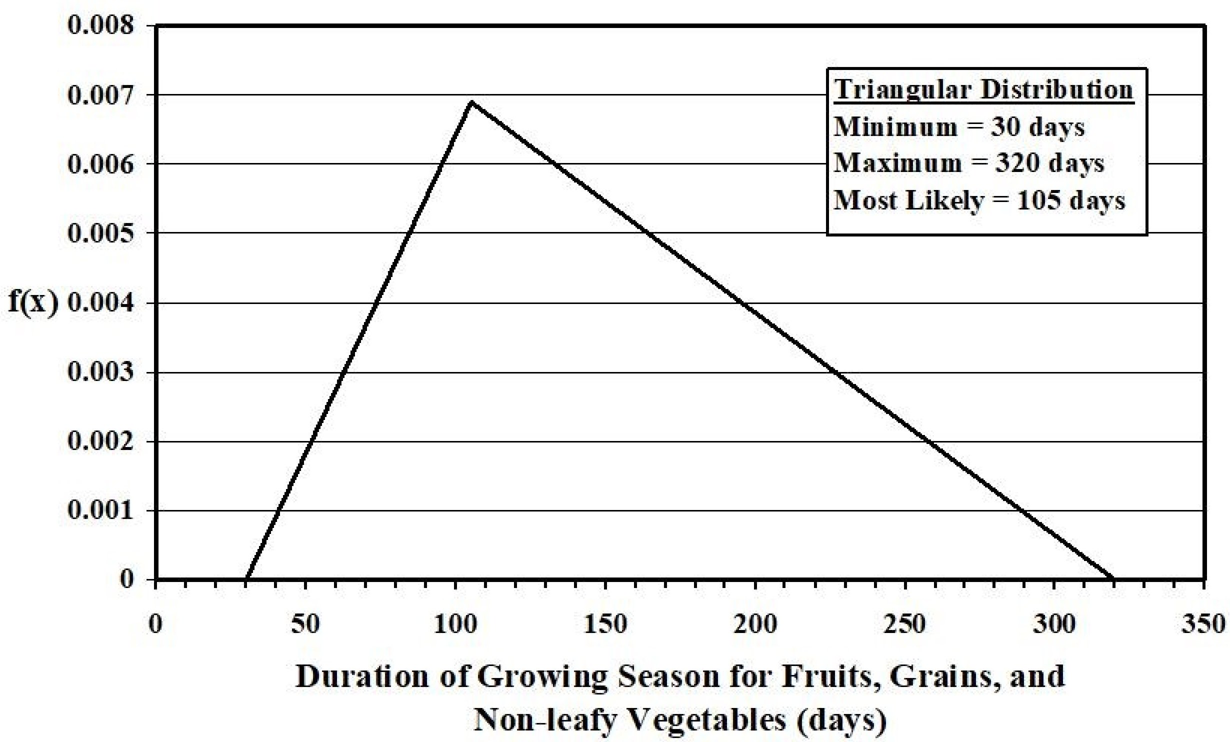

Figure C-52 Probability Density Function for Fruits, Grains, and Non-Leafy Vegetables for Duration of Growing Season

Table C-80 lists the data extracted from Allen et al. (1998) for different leafy vegetables. For leafy vegetables, it is expected that foliar deposition during the time between initial crop development and the time of harvest could contribute to the dose of contamination that is ingested when the leafy vegetables are consumed. Therefore, the total time taken from crop development to the start of harvest is used to develop a distribution for leafy vegetables. The proposed growing period for leafy vegetables (Figure C-53) is represented by a triangular distribution with minimum = 40 days, most likely = 75 days, and maximum = 180 days.

Table C-80 Time (Days) Taken by Different Leafy Vegetables during Four Stages of Growth

Leafy Vegetables	Initial	Crop Development	Start of Maturity	Harvest	Total (from crop development to harvest)
Broccoli	35	45	40	15	100
Cabbage	40	60	50	15	125
Cauliflower	35	50	40	15	105
Celery	25-30	40-55	45-105	15-20	100-180
Crucifers	20-30	30-35	20-90	10-40	60-165
Lettuce	20-35	30-50	15-45	10	55-105
Onion (green)	20-30	30-55	10-55	5-40	45-150
Spinach	20	20-30	15-40	5-10	40-80

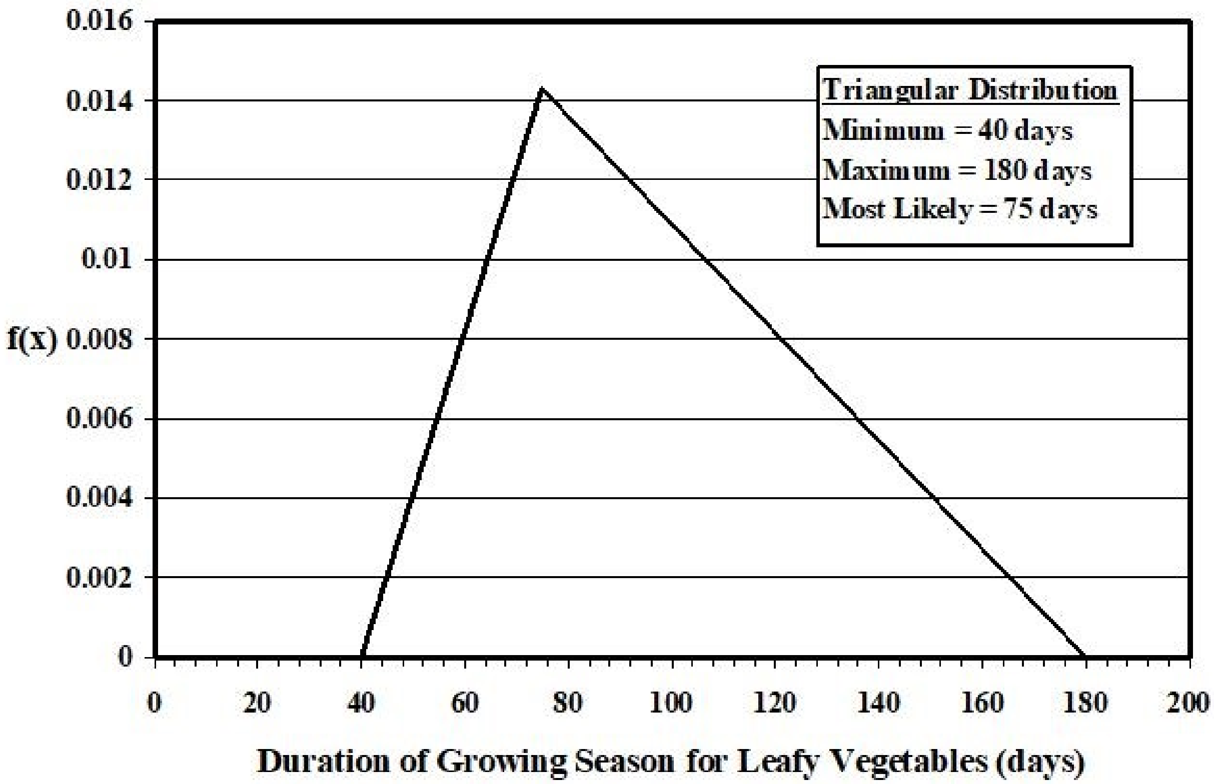

Figure C-53 Probability Density Function for Leafy Vegetables for the Duration of Growing Season

C.6.3 Transfer Factors for Plants

Applicable Code: RESRAD-ONSITE and RESRAD-OFFSITE

Description: The soil-to-plant transfer factor is defined as the ratio of radionuclide concentration in the plant food product at the time of harvest (fresh weight basis) to that of soil radionuclide concentration (dry weight basis; Yu et al., 2015). These parameters are used when the plant, meat, or milk ingestion pathways are active. The RESRAD-ONSITE and RESRAD-OFFSITE codes use composite values of plant transfer factors. Differences among food crops (such as nonleafy vegetables, root vegetables, fruits, and grain) are not considered in RESRAD-ONSITE and RESRAD-OFFSITE codes. Differences among consumption groups (such as humans and animals) are not considered in RESRAD-ONSITE code.

Units: picocuries per gram plant (wet) per picocuries per gram soil (dry; pCi/g per pCi/g)

Probabilistic Input:

Distribution: truncated lognormal-n

Defining Values for Distribution: Values are assigned according to the element of the radioactive isotope as given in Table C-81. Lower and upper quantile input values are 0.0001 and 0.999 for all elements.

Discussion: Three plant categories—fruit, grain, andnon-leafy vegetables; leafy vegetables; and pasture silage—are used in the ONSITE code, and four plant categories—fruit, grain, and non-leafy vegetables; leafy vegetables; pasture silage; and livestock feed grain—are used in the OFFSITE code. The first two plant categories (fruit, grain, and non-leafy vegetables and leafy vegetables) are for human consumption, and fodder, pasture silage, and feed grain are for animal consumption.

The probabilistic dose analysis capability was developed for the ONSITE code in 2000 (Yu et al. 2000), and a plant transfer factor distribution was developed for 74 elements. The plant/soil transfer factors were obtained mainly from Appendix D of the National Council on Radiation Protection and Measurements Report 129 (NCRP, 1999). The current versions of ONSITE and OFFSITE code has many more radionuclides in its database. New information has been collected/complied for plant transfer factor in the recently published data collection handbook (Yu et al. 2015). The data collection handbook compared the default plant transfer factors and distributions in Yu et al. (2000) with other published literature (Staven et al. 2003; IAEA 2009, 2010a; and Napier et al. 2014). The data collection handbook also compiled plant transfer factors for different plant types (leafy vegetables, fruits, grain, and root vegetables from Stavern et al. 2003 and 14 plant groups from IAEA 2010a).

A lognormal distribution is proposed as most appropriate for the plant/soil transfer factor. Since NCRP report (NCRP, 1999) has the comprehensive dataset as required in the ONSITE and OFFSITE codes, this report was used as basis for the plant transfer factor distributions.

Table C-81 Lognormal Distribution Parameter Values for Plant/Soil Transfer Factors

Element	GM	GSD	μ	σ
Ac	1.0E-03	3.0	-6.9	1.1
Ag	4 0E-03	2.5	-5.5	0.9
Al	4 0E-03	3.0	-5.5	1.1
Am	1 0E-03	2.5	-6.9	0.9
As	8 0E-02	3.0	-2.5	1.1
At	2 0E-01	3.0	-1.6	1.1
Au	1 0E-01	3.0	-3.1	1.1
B	1 0E-02	3.0	-4.6	1.1
Ba	1 0E-02	2.5	-4.6	0.9
Be	4 0E-03	3.0	-5.5	1.1
Bi	1 0E-01	3.0	-3.1	1.1
Bk	1 0E-03	3.0	-6.9	1.1
Br	4 0E-01	3.0	-0.9	1.1
C[a]	NR	NR	NR	NR
Ca	5 0E-01	3.0	-0.7	1.1
Cd	5 0E-01	3.0	-0.7	1.1
Ce	2 0E-03	2.7	-6.2	1.0
Cf	1 0E-03	3.0	-6.9	1.1
Cl	2×10^1	3.0	3.0	1.1
Cm	1 0E-03	2.5	-6.9	0.9
Co	8 0E-02	2.5	-2.5	0.9
Cr	1 0E-02	2.7	-4.6	1.0
Cs	4 0E-02	2.7	-3.2	1.0
Cu	5 0E-02	2.7	-3.0	1.0
Dy	2 0E-03	3.0	-6.2	1.1
Er	2 0E-03	3.0	-6.2	1.1
Es	1 0E-03	3.0	-6.9	1.1
Eu	2 0E-03	3.0	-6.2	1.1
F	2 0E-02	3.0	-3.9	1.1
Fe	1 0E-03	2.7	-6.9	1.0
Fm	2 0E-03	3.0	-6.2	1.1
Fr	3 0E-02	3.0	-3.5	1.1
Ga	3 0E-03	3.0	-5.8	1.1
Gd	2 0E-03	3.0	-6.2	1.1
Ge	4 0E-01	3.0	-0.9	1.1
H[a]	NR	NR	NR	NR
Ha	2 0E-03	3.0	-6.2	1.1
Hf	3 0E-03	3.0	-5.8	1.1
Hg	3 0E-01	3.0	-1.2	1.1
Ho	2 0E-03	3.0	-6.2	1.1
I	2 0E-02	2.5	-3.9	0.9
In	3 0E-03	3.0	-5.8	1.1
Ir	3 0E-02	3.0	-3.5	1.1
K	3 0E-01	3.0	-1.2	1.1
La	2 0E-03	2.5	-6.2	0.9

[a] NR = no user input for C and H, but the values are computed by the code as described in Appendix L of Yu et al. (2001).
Source: NCRP (1999), except as noted.

Table C-81 Lognormal Distribution Parameter Values for Plant/Soil Transfer Factors (cont.)

Element	GM	GSD	μ	σ
Lu	2 0E-03	3.0	-6.2	1.1
Md	2 0E-03	3.0	-6.2	1.1
Mg	3 0E-02	3.0	-3.5	1.1
Mn	3 0E-01	2.5	-1.2	0.9
Mo	1 0E-01	2.7	-1.6	1.0
N[a]	3 0E+01	2.5	-3.4	0.9
Na	5 0E-02	2.7	-3.0	1.0
Nb	1 0E-02	2.7	-4.6	1.0
Nd	2 0E-03	3.0	-6.2	1.1
Ni	5 0E-02	2.5	-3.0	0.9
No	2 0E-03	2.7	-6.2	1.0
Np	2 0E-02	2.5	-3.9	0.9
No	2 0E-03	2.7	-6.2	1.0
Np	2 0E-02	2.5	-3.9	0.9
Os	3 0E-02	3.0	-3.5	1.1
P	1 0E+00	3.0	0.0	1.1
Pa	1 0E-02	3.0	-4.6	1.1
Pb	4 0E-03	2.5	-5.5	0.9
Pd	1 0E-01	3.0	-3.1	1.1
Pm	2 0E-03	3.0	-6.2	1.1
Po	1 0E-03	2.5	-6.9	0.9
Pr	2 0E-03	2.7	-6.2	1.0
Pt	1 0E-01	3.0	-3.1	1.1
Pu	1 0E-03	2.5	-6.9	0.9
Ra	4 0E-02	2.5	-3.2	0.9
Rb	2 0E-01	2.7	-1.6	1.0
Re	2 0E-01	3.0	-1.6	1.1
Rh	3 0E-02	2.7	-3.5	1.0
Ru	3 0E-02	2.5	-3.5	0.9
S	6 0E-01	3.0	-0.5	1.1
Sb	1 0E-02	2.7	-4.6	1.0
Sc	2 0E-03	3.0	-6.2	1.1
Se	1 0E-01	3.0	-3.1	1.1
Si	2 0E-02	3.0	-3.9	1.1
Sm	2 0E-03	3.0	-6.2	1.1
Sn	3 0E-01	3.0	-1.2	1.1
Sr	3 0E-01	2.7	-1.2	1.0
Ta	2 0E-03	3.0	-6.2	1.1
Tb	2 0E-03	3.0	-6.2	1.1
Tc	5 0E+00	2.5	1.6	0.9
Te	1 0E-01	2.7	-3.1	1.0
Th	1 0E-03	2.5	-6.9	0.9
Ti	5 0E-04	3.0	-7.6	1.1
Tl	2 0E-01	3.0	-1.6	1.1

[a] NR = no user input for C and H, but the values are computed by the code as described in Appendix L of Yu et al. (2001).
Source: NCRP (1999), except as noted.

Table C-81 Lognormal Distribution Parameter Values for Plant/Soil Transfer Factors (cont.)

Element	GM	GSD	μ	σ
Tm	2 0E-03	3.0	-6.2	1.1
U	2 0E-03	2.5	-6.2	0.9
V	2 0E-03	3.0	-6.2	1.1
W	8 0E-01	2.7	-0.2	1.0
Y	2 0E-03	3.0	-6.2	1.1
Yb	2 0E-03	2.7	-6.2	1.0
Zn	4 0E-01	2.5	-0.9	0.9
Zr	1 0E-03	2.7	-6.9	1.0

[a] NR = no user input for C and H, but the values are computed by the code as described in Appendix L of Yu et al. (2001).
Source: NCRP (1999), except as noted.

C.6.4 Transfer Factors for Meat

Applicable Code: RESRAD-ONSITE and RESRAD-OFFSITE

Description: The radionuclide transfer factor for meat is the equilibrium ratio of the concentration of a radionuclide in fresh meat (pCi/kg) to the rate of daily dietary intake of that radionuclide (pCi/d) by the meat animal (Yu et al., 2015). This parameter is used when the meat ingestion pathway is active. The default transfer factors in the ONSITE and OFFSITE codes are for beef. If the predominant meat source is other than beef, the transfer factors should be changed accordingly.

Units: picocuries per gram plant (wet) per picocuries per gram soil (dry; pCi/g per pCi/g)

Probabilistic Input:

Distribution: truncated lognormal-n

Defining Values for Distribution: Values are assigned according to the element of the radioactive isotope as given in Table C-82. Lower and upper quantile input values are 0.0001 and 0.999 for all elements.

Discussion: The probabilistic dose analysis capability was developed for the ONSITE code in 2000 (Yu et al. 2000), and a meat transfer factor distribution was developed for 72 elements. The current versions of ONSITE and OFFSITE code has many more radionuclides in its database. New information has been collected/complied for meat transfer factor in the recently published data collection handbook (Yu et al. 2015). The data collection compared the default meat transfer factors and distributions in Yu et al. (2000) with other published literature (Staven et al. 2003 and IAEA 2009, 2010a). The data collection handbook also compiled meat transfer factors for goat, mutton, pork, poultry, egg from IAEA (2010a) and poultry and egg from Staven et al. (2003). However, Staven et al. (2003) does not provide distribution for the meat transfer factor. To select the values in Table C.6.4-1 for meat transfer factor distributions, the most recent IAEA Technical Report Series No. 472 (IAEA 2010a) is given first priority. The second reference used is NCRP Report No. 129 (NCRP 1999) because of its general acceptance in the dose assessment community.

Table C-82 Lognormal Distribution Parameter Values for the Transfer Factors for Meat (Beef)

Element	μ	σ
Ac	-10.82	1
Ag	-5.81	0.7
Al	-7.6	1
Am	-9.9	0.4
As	-3.91	1
At	-4.61	1
Au	-5.3	1
B	-7.13	1
Ba	-8.52	0.9
Be	-5.3	1
Bi	-6.21	1
Bk	-10.82	1
Br	-3	1
C[a]	NR	NR
Ca[b]	-4.34	3.4
Cd[b]	-5.15	2.1
Ce	-10.82	0.9
Cf	-9.72	1
Cl	-3.22	0.7
Cm	-10.82	1
Co[b]	-7.75	0.8
Cr	-3.51	0.4
Cs[b]	-3.82	0.9
Cu	-4.61	0.4
Dy	-6.21	1
Er	-6.21	1
Es	-10.82	1
Eu	-6.21	1
F	-3.91	1
Fe[b]	-4.27	0.4
Fm	-8.52	1
Fr	-3.51	1
Ga	-8.11	1
Gd	-6.21	1
Ge	-1.61	1
H[a]	NR	NR
Ha	-12.21	1

[a] NR = no user input for C and H, but the values are computed by the code as described in Appendix L of Yu et al. (2001).
[b] Transfer factor distribution is from IAEA (2010a)..
[c] NA = value not available.
Source: NCRP (1999) except as noted.
Note: μ = mean of the underlying normal distribution, and σ = standard deviation of the underlying normal distribution.

Table C-82 Lognormal Distribution Parameter Values for the Transfer Factors for Meat (Beef) (cont.)

Element	μ	σ
Hf	-7.82	1
Hg	-4.61	1
Ho	-6.21	1
I[b]	-5.01	1.2
In	-5.52	1
Ir	-6.21	1
K	-3.91	0.2
La[b]	-8.95	0.2
Lu	-6.21	1
Md	-8.52	1
Mg	-5.81	0.2
Mn	-6.91	0.7
Mo	-6.91	0.9
N[c]	NA	NA
Na	-2.53	0.2
Nb	-13.82	0.9
Nd	-6.21	1
Ni	-5.3	0.9
Ne	-8.52	1
Np	-6.91	0.7
O[c]	NA	NA
Os	-6.21	1
P	-3	0.2
Pa	-12.21	1
Pb[b]	-7.26	0.9
Pd	-8.52	1
Pm	-6.21	1
Po	-5.3	0.7
Pr	-6.21	1
Pt	-8.52	1
Pu[b]	-13.72	3.2
Ra	-6.91	0.7
Rb	-3.51	0.7
Re	-4.61	1
Rh	-6.21	1
Ru[b]	-5.71	0.6
S	-1.61	1
Sb	-6.91	0.9

[a] NR = no user input for C and H, but the values are computed by the code as described in Appendix L of Yu et al. (2001).
[b] Transfer factor distribution is from IAEA (2010a)..
[c] NA = value not available.
Source: NCRP (1999) except as noted.
Note: μ = mean of the underlying normal distribution, and σ = standard deviation of the underlying normal distribution.

Table C-82 Lognormal Distribution Parameter Values for the Transfer Factors for Meat (Beef) (cont.)

Element	μ	σ
Sc	-6.21	1
Se	- 3.16	0.9
Si	-8.11	1
Sm	-6.21	1
Sn	-4.61	1
Sr[b]	-6.65	1.1
Ta	-12.21	1
Tb	-6.21	1
Tc	-9.21	0.7
Te	-4.96	0.9
Th[b]	-8.38	1.1
Ti	-3.91	1
Tl	-3.91	1
Tm	-6.21	1
U[b]	-7.85	0.5
V	-4.61	1
W	-3.22	0.9
Y	-6.21	0.9
Yb	-6.21	1
Zn[b]	-1.83	1.2
Zr	-13.82	0.9

[a] NR = no user input for C and H, but the values are computed by the code as described in Appendix L of Yu et al. (2001).
[b] Transfer factor distribution is from IAEA (2010a)..
[c] NA = value not available.
Source: NCRP (1999) except as noted.
Note: μ = mean of the underlying normal distribution, and σ = standard deviation of the underlying normal distribution.

C.6.5 Transfer Factors for Milk

Applicable Code: RESRAD-ONSITE and RESRAD-OFFSITE

Description: The radionuclide transfer factor for milk is the ratio of the concentration of a radionuclide in fresh milk (pCi/L) to the rate of daily dietary intake of that radionuclide (pCi/d) by the milk animal (Yu et al., 2015). This parameter is used when the milk ingestion pathway is active. The default transfer factors in the ONSITE and OFFSITE codes are for cow's milk. If the human food source is other than cow's milk (e.g., goat's milk), the transfer factors should be changed accordingly.

Units: picocuries per kilogram per picocuries per day (pCi/L per pCi/d)

Probabilistic Input:

Distribution: truncated lognormal-n

Defining Values for Distribution: Values are assigned according to the element of the radioactive isotope as given in Table C-83. Lower and upper quantile input values are 0.0001 and 0.999 for all elements.

Discussion: The probabilistic dose analysis capability was developed for the RESRAD-ONSITE code in 2000 (Yu et al. 2000), and a milk transfer factor distribution was developed for 70 elements. The current versions of ONSITE and OFFSITE code has many more radionuclides in its database. New information has been collected/complied for meat transfer factor in the recently published data collection handbook (Yu et al. 2015). The data collection compared the default milk transfer factors and distributions in Yu et al. (2000) with other published literature (Staven et al. 2003 and IAEA 2009, 2010a). However, Staven et al. (2003) does not provide distribution for the milk transfer factor. The data collection handbook also compiled milk transfer factors for goat milk and sheep milk from IAEA (2010a). To select the values in Table C-83 for milk transfer factor distributions, the most recent IAEA Technical Report Series No.472 (IAEA 2010a) is given first priority. The second reference used is NCRP Report No. 129 (NCRP 1999) because of its general acceptance in the dose assessment community.

Table C-83 Lognormal Distribution Parameter Values for the Transfer Factors for Milk (Cow)

Element	μ	σ
Ac	-13.12	0.9
Ag	-5.12	0.7
Al	-8.52	0.9
Am	-13.12	0.7
As	-9.21	0.9
At	-4.61	0.9
Au	-11.51	0.9
B	-5.81	0.9
Ba[b]	-8.74	1
Be	-13.12	0.9
Bi	-6.91	0.9
Bk	-13.12	0.9
Br	-3.91	0.9
C[a]	NR	NR
Ca[b]	-4.61	0.5
Cd[b]	-8.57	2.7
Ce[b]	-10.82	1.8
Cf	-13.12	0.9
Cl	-3.91	0.5
Cm	-13.12	0.9
Co[b]	-9.12	0.7
Cr[b]	-7.75	3.3

[a] NR = no user input for C and H, but the values are computed by the code as described in Appendix L of Yu et al. (2001).
[b] Transfer factor distribution is from IAEA (2010a).
[c] NA = value not available.
Source: NCRP (1999) except as noted.
Note: μ = mean of the underlying normal distribution, and σ = standard deviation of the underlying normal distribution.

Table C-83 Lognormal Distribution Parameter Values for the Transfer Factors for Milk (Cow) (cont.)

Element	μ	σ
Cs[b]	-5.38	0.7
Cu	-6.21	0.9
Dy	-9.72	0.9
Er	-9.72	0.9
Es	-14.73	0.9
Eu	-9.72	0.9
F	-4.96	0.9
Fe[b]	-10.26	0.7
Fm	-11.74	0.9
Fr	-4.83	0.9
Ga	-11.51	0.9
Gd	-9.72	0.9
Ge	-4.61	0.9
H[a]	NR	NR
Ha	-12.21	0.9
Hf	-10.82	0.9
Hg	-7.6	0.7
Ho	-9.72	0.9
I[b]	-5.22	0.9
In	-8.52	0.9
Ir	-13.12	0.9
K	-4.96	0.5
La[b]	-9.72	0.9
Lu	-9.72	0.9
Md	-12.21	0.9
Mg	-4.83	0.7
Mn[b]	-10.1	1.6
Mo[b]	-6.81	0.8
N[c]	NA	NA
Na[b]	-4.34	0.7
Nb[b]	-13.12	0.7
Nd	-9.72	0.9
Ni	-3.91	0.7
Ne	-12.21	0.9
Np	-11.51	0.7
O[c]	NA	NA
Os	-9.21	0.9
P	-3.91	0.7
Pa	-12.21	0.9
Pb	-8.11	0.9

[a] NR = no user input for C and H, but the values are computed by the code as described in Appendix L of Yu et al. (2001).
[b] Transfer factor distribution is from IAEA (2010a).
[c] NA = value not available.
Source: NCRP (1999) except as noted.
Note: μ = mean of the underlying normal distribution, and σ = standard deviation of the underlying normal distribution.

Table C-83 Lognormal Distribution Parameter Values for the Transfer Factors for Milk (Cow) (cont.)

Element	μ	σ
Pd	-9.21	0.9
Pm	-9.72	0.9
Po[b]	-8.47	0.6
Pr	-9.72	0.9
Pt	-9.21	0.9
Pu[b]	-13.82	0.5
Ra[b]	-7.88	0.8
Rb	-4.61	0.7
Re	-6.21	0.9
Rh	-7.6	0.9
Ru[b]	-11.57	2.1
S[b]	-3.91	0.7
Sb[b]	-10.18	0.9
Sc	-5.12	0.9
Se[b]	-5.52	0.7
Si	-10.82	0.9
Sm	-9.72	0.9
Sn	-6.91	0.9
Sr[b]	-6.65	0.5
Ta	-12.21	0.9
Tb	-9.72	0.9
Tc	-6.91	0.7
Te[b]	-7.99	0.9
Th	-12.21	0.9
Ti	-4.61	0.9
Tl	-5.81	0.9
Tm	-9.72	0.9
U[b]	-6.32	1.3
V	-7.6	0.9
W[b]	-8.57	1.1
Y	-9.72	0.9
Yb	-9.72	0.9
Zn[b]	-5.91	1.4
Zr[b]	-12.53	1.5

[a] NR = no user input for C and H, but the values are computed by the code as described in Appendix L of Yu et al. (2001).
[b] Transfer factor distribution is from IAEA (2010a).
[c] NA = value not available.
Source: NCRP (1999) except as noted.
Note: μ = mean of the underlying normal distribution, and σ = standard deviation of the underlying normal distribution.

C.6.6 Wet-Weight Crop Yields for Non-Leafy Vegetables

Applicable Code: RESRAD-ONSITE, RESRAD-OFFSITE

Description: The wet weight crop yield is the quantity of non-leafy vegetables that can be produced over an area of land. This parameter is used in calculating the plant-food/soil concentration ratio for foliar deposition and the plant-food/water concentration ratio for overhead irrigation.

Units: kilograms per square meter (kg/m^2)

Probabilistic Input:

Distribution: truncated lognormal-n

Defining Values for Distribution:

Underlying mean value: 0.56Lower quantile value: 0.001

Underlying standard deviation: 0.48 Upper quantile value: 0.999

Discussion: Crop yields vary from state to state. The USDA publishes an annual statistical bulletin listing production rates and estimated crop values for all food commodities. Data from the statistical bulletin Vegetables: Final Estimates by States, 1992-1997 (USDA, 1999) were used to estimate the crop yields for non-leafy vegetables.[3] The crop yields were found to remain relatively constant over the 6-year interval covered by the report. The data varied the greatest from state to state, with Oklahoma having the smallest non-leafy crop yield (0.6 kg/m^2) and Idaho having the largest (6.8 kg/m^2). The probability distribution function reflects the variance in crop production over the 50 states.

The non-leafy crop yield for a particular state was estimated by subtracting the production rates for leafy vegetables from the total vegetable production rate. States with the largest leafy vegetable production included California, Arizona, and Florida (USDA, 1999). Since the annual crop yields did not vary much over the 6-year period, data from 1992 were used to estimate the non-leafy vegetable crop yields for each state. The non-leafy vegetable crop yield was assumed to be distributed lognormally, and the parameters of the lognormal distribution were estimated from 1992 data for all 50 states. The crop yields were weighted on the basis of the size of the agricultural area of the state. Bayesian techniques were used to estimate the posterior probability densities for the parameters μ and σ. The posterior means for both parameters were then estimated, and these values were used as the defining values for the probability distribution for the wet weight crop yield. Figure C-54 presents the probability density function.

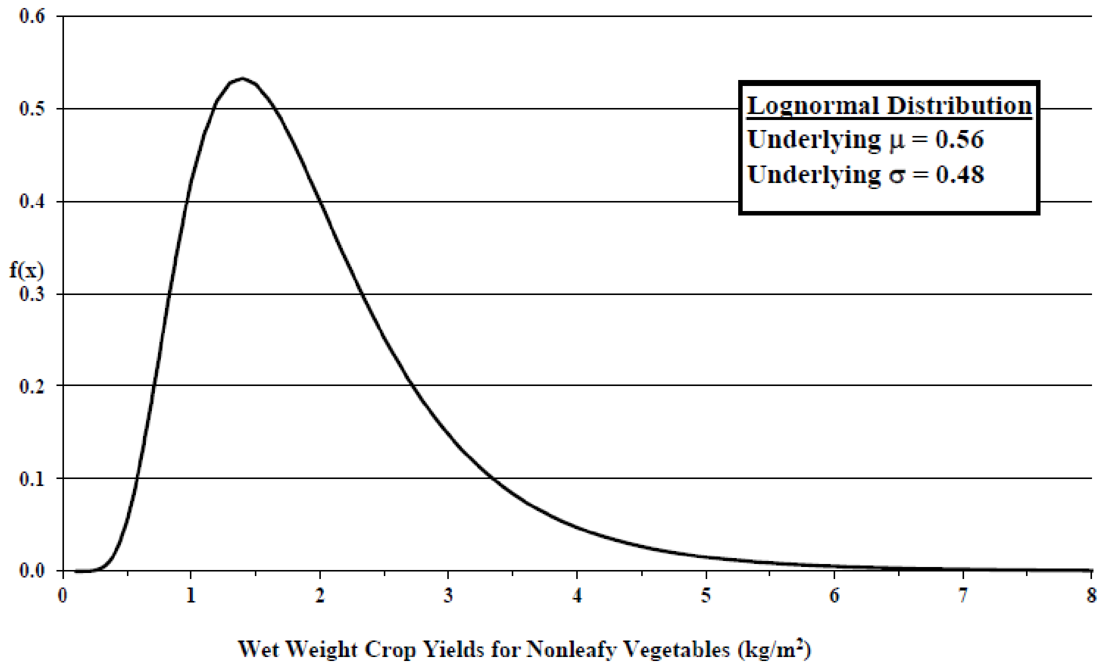

Figure C-54 Wet Weight Crop Yields for Non-Leafy Vegetables Probability Density Function

C.6.7 Weathering Removal Constant

Applicable Code: RESRAD-ONSITE, RESRAD-OFFSITE

Description: Some of the airborne contaminants that are intercepted and initially retained by the foliage of plants are removed from the plant by a number processes. This removal is modeled by an exponential function of time, and the rate of removal is represented in RESRAD-ONSITE and RESRAD-OFFSITE by the weathering removal constant.

Units: $year^{-1}$

Probabilistic Input:

Distribution: triangular

Defining values for distribution:

Minimum: 5.1 Maximum: 84 Most likely: 18

Discussion: The concentration of contaminants initially intercepted and retained by the foliage of plants decreases over time because of a number of removal processes, including radioactive decay, wash off, wind action, dilution by new growth, and volatilization (IAEA, 1994). This reduction is modeled in RESRAD by a first order removal rate termed the “weathering removal rate,” λ_w. Two related parameters are the retention half-life, $T_{½}$, and the residence time or time constant, τ. These parameters are related by:

$$\lambda_w = \frac{1}{\tau} = \frac{ln2}{T_{1/2}} \tag{C-24}$$

Brown et al. (1997) report values for the retention half-life submitted by a number experts. These values were converted to removal constants and were used to estimate the values for the triangular distribution suggested here. Retention half-life values ranged from 2–15 days for 5th percentile estimates, 7–30 days for 50th percentile estimates, and 15–50 days for 95th percentile estimates (Brown et al., 1997). Estimates varied in part because of effects specific to plant type and radionuclide species. Maximum, minimum, and most likely retention half-lives of 50, 3, and 14 days were selected. These values correspond to minimum, maximum, and most likely values of 5.1, 84, and 18 yr^{-1}, respectively, for the weathering removal constant. The probability density function is shown in Figure C-55.

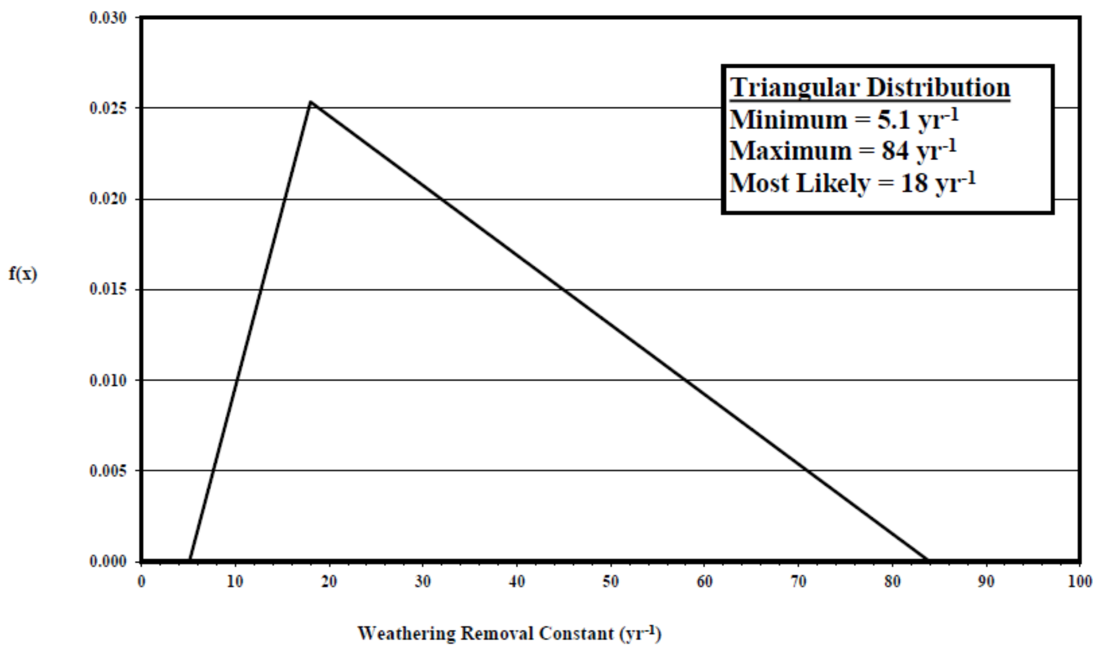

Figure C-55 Weathering Removal Constant Probability Density Function

C.6.8 Wet Foliar Interception Fraction for Leafy Vegetables

Applicable Code: RESRAD-ONSITE, RESRAD-OFFSITE

Description: This parameter represents the fraction of airborne contamination wet deposited on an agricultural or pasture area that is intercepted and initially retained by the foliage of leafy vegetables.

Units: no units

Probabilistic Input:

Distribution: triangular

Defining values for distribution:

Minimum: 0.06Maximum: 0.95Most likely: 0.67

Discussion: Retention of wet-deposited contaminants on vegetation is strongly influenced by both the ionic nature of the contaminant species and the amount of rainfall at the time of deposition. Anions are retained less than insoluble particulates or cations because plant surfaces tend to have a negative charge (Hoffman et al., 1995; Prohl et al., 1995). Thus, chemical species with a higher positive charge tend to be retained the most. The amount of rainfall in a discrete rain event also plays an important part in the amount of deposited contamination that is initially retained (Prohl et al., 1995). The larger the amount of rainfall in the overall event, the less intercepted contamination is retained.

Only an approximation of the probability density function for the wet foliar interception fraction can be made because of the broad application of the distribution in RESRAD-ONSITE and RESRAD-OFFSITE to all event types (i.e., different species and rainfall amounts) and because limited data are available for only a few chemical species and associated rainfall amounts. Brown et al. (1997) report values for the wet foliar interception fraction solicited from a number of experts. Wet foliar interception factors for green vegetables ranged from 0.03–0.6 for 5th percentile estimates, 0.05–0.8 for 50th percentile estimates, and 0.8–1.0 for ninety-5th percentile estimates (Brown et al., 1997). Minimum, maximum, and most likely interception fractions of 0.06, 0.95, and 0.67 were selected for use in a triangular distribution. The probability density function is shown in Figure C-56.

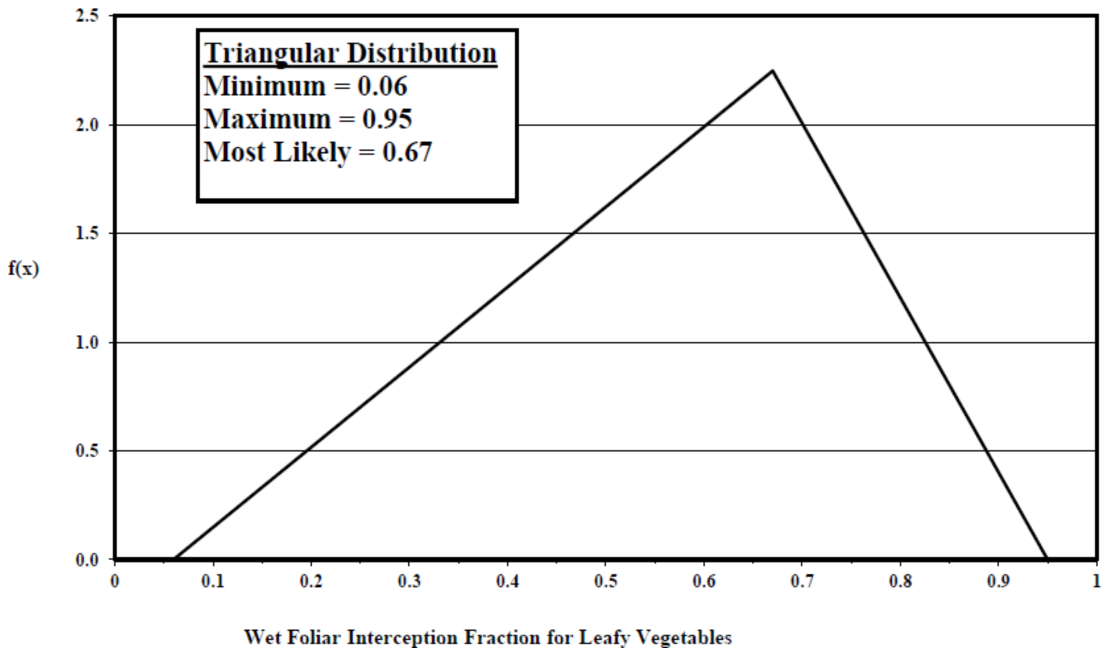

Figure C-56 Wet Foliar Interception Fraction Probability Density Function

C.6.9 Bioaccumulation Factors for Fish

Applicable Code: RESRAD-ONSITE and RESRAD-OFFSITE

Description: The bioaccumulation factor for an aquatic organism or tissue is the ratio of the concentration of a radionuclide in the whole organism or tissue (pCi/kg) to the concentration of that same radionuclide in water (pCi/L; Yu et al., 2015). This parameters is used when the aquatic food ingestion pathway is active. The default transfer factors in the ONSITE and OFFSITE codes include two aquatic food types—fish and crustacea—and are for freshwater (FW) applications only. For the marine environment application, the values should be appropriately changed.

Units: picocuries per kilogram (of tissue) on wet weight basis per picocuries per liter (of water) (pCi/kg per pCi/L)

Probabilistic Input:

Distribution: lognormal-n

Defining values for distribution: Values are assigned according to the element of the radioactive isotope as given in Table C-84

Discussion: The probabilistic dose analysis capability was developed for the ONSITE code in 2000 (Yu et al. 2000), and a fish bioaccumulation factor distribution was developed for 72 elements. The current versions of ONSITE and OFFSITE code has many more radionuclides in its database. New information has been collected/complied for fish bioaccumulation factor in the recently published data collection handbook (Yu et al. 2015). The data collection handbook compared the default bioaccumulation factor for fish in Yu et al. (2000) with other published literature (NCRP 1996, Staven et al. 2003, and IAEA 2009, 2010a). The data collection handbook also compiled salt water fish bioaccumulation factors from PNNL report (Staven et al. 2003) and NCRP (1996) and freshwater whole fish and fish muscle from IAEA (2010a) report.

To select the values in Table C-84 for fish bioaccumulation factor distributions, the most recent IAEA Technical Report Series No. 472 (IAEA 2010a) is given first priority; i.e., if the parameter distribution for fish bioaccumulation factor is available from IAEA 2010a, distribution from Yu et al. (2000) is replaced with the latest value from IAEA 2010a. For the elements not in Yu et al. (2000) and the parameter value or distribution is not available from IAEA 2010a, the second reference chosen was the PNNL report (Staven et al. 2003). The fish bioaccumulation factors in the PNNL report were used in the GENII system of computer codes. The third preference is given to the NCRP Report (NCRP 1996) because of its general acceptance in the dose assessment community. It was assumed that the bioaccumulation factors were distributed lognormally. For the elements for which parameter distributions were not available, the values for the parameter μ (the underlying mean) for the lognormal distributions were obtained by taking the natural logarithm of the suggested value. Since bioaccumulation factors can range over orders of magnitude, the geometric standard deviation was set to 3, and the parameter σ (standard deviation) for the lognormal distribution was estimated by taking the natural logarithm of the geometric standard deviation.

Table C-84 Lognormal Distribution Parameter Values for Bioaccumulation Factors for Fish

Element	μ	σ
Ac[a]	3.2E+00	1.1
Ag[b]	4.7E+00	0.4
Al[b]	3.9E+00	1.4
Am[b]	5.5E+00	1.1
As[b]	5.8E+00	0.7
At[c]	2.7E+00	1.1
Au[b]	5.5E+00	0.7
B[c]	1.6E+00	1.1
Ba[b]	2.0E-01	1.2
Be[a]	4.6E+00	1.1
Bi[a]	2.7E+00	1.1
Bk[c]	3.2E+00	1.1
Br[b]	4.5E+00	0.8
C[b]	1.3E+01	1.1
Ca[b]	2.5E+00	0.9
Cd[a]	5.3E+00	1.1
Ce[b]	3.2E+00	2.3

[a] Bioaccumulation factor value is from Staven et al. (2003).
[b] Bioaccumulation factor distribution is from IAEA (2010a).
[c] Bioaccumulation factor value is from NCRP (1996).
Sources: IAEA (2010a), Staven et al. (2003), and NCRP (1996) as noted.
Note: μ = mean of the underlying normal distribution, and σ = standard deviation of the underlying normal distribution.

Table C-84 Lognormal Distribution Parameter Values for Bioaccumulation Factors for Fish (cont.)

Element	μ	σ
Cf[a]	3.2E+00	1.1
Cl[b]	3.9E+00	0.8
Cm[a]	3.4E+00	1.1
Co[b]	4.3E+00	0.9
Cr[b]	3.7E+00	0.7
Cs[b]	7.8E+00	0.9
Cu[b]	5.4E+00	0.5
Dy[a]	3.4E+00	1.1
Er[a]	3.4E+00	1.1
Es[c]	3.2E+00	1.1
Eu[b]	4.9E+00	1.6
F[a]	2.3E+00	1.1
Fe[b]	5.1E+00	1.9
Fm[c]	2.3E+00	1.1
Fr[c]	3.4E+00	1.1
Ga[a]	6.0E+00	1.1
Gd[a]	3.4E+00	1.1
Ge[c]	8.3E+00	1.1
H[c]	0.0E+00	0.1
Hf[b]	7.0E+00	0.6
Hg[b]	8.7E+00	0.6
Ho[a]	3.4E+00	1.1
I[b]	3.4E+00	0.9
In[a]	9.2E+00	1.1
Ir[a]	2.3E+00	1.1
K[b]	8.1E+00	0.5
La[b]	3.6E+00	1.6
Li[c]	0.0E+00	1.1
Lr[c]	2.3E+00	1.1
Lu[c]	3.2E+00	1.1
Md[c]	2.3E+00	1.1
Mg[b]	3.6E+00	0.8
Mn[b]	5.5E+00	1.9
Mo[b]	6.0E-01	0.7
N[a]	1.2E+01	1.1
Na[b]	4.3E+00	1.1
Nb[a]	5.7E+00	1.1
Nd[a]	3.4E+00	1.1
Ni[b]	3.0E+00	0.6
Np[a]	3.0E+00	1.1
O[a]	0.0E+00	1.1

[a] Bioaccumulation factor value is from Staven et al. (2003).
[b] Bioaccumulation factor distribution is from IAEA (2010a).
[c] Bioaccumulation factor value is from NCRP (1996).
Sources: IAEA (2010a), Staven et al. (2003), and NCRP (1996) as noted.
Note: μ = mean of the underlying normal distribution, and σ = standard deviation of the underlying normal distribution.

Table C-84 Lognormal Distribution Parameter Values for Bioaccumulation Factors for Fish (cont.)

Element	μ	σ
Os[b]	1.2E+01	0.1
P[a]	1.1E+01	1.1
Pa[a]	2.3E+00	1.1
Pb[b]	3.2E+00	1.1
Pd[a]	2.3E+00	1.1
Pm[a]	3.4E+00	1.1
Po[b]	3.6E+00	1.5
Pr[a]	3.4E+00	1.1
Pt[c]	3.6E+00	1.1
Pu[b]	1.0E+01	1
Ra[b]	1.4E+00	1.9
Rb[b]	8.5E+00	0.5
Re[a]	4.8E+00	1.1
Rf[c]	3.7E+00	1.1
Rh[a]	2.3E+00	1.1
Ru[a]	4.6E+00	1.1
S[a]	6.7E+00	1.1
Sb[b]	3.6E+00	1.5
Sc[b]	5.2E+00	0.7
Se[b]	8.7E+00	0.3
Si[a]	3.0E+00	1.1
Sm[a]	3.4E+00	1.1
Sn[a]	8.0E+00	1.1
Sr[b]	1.1E+00	1.4
Ta[a]	5.7E+00	1.1
Tb[b]	6.0E+00	0.6
Tc[a]	3.0E+00	1.1
Te[b]	5.0E+00	0.4
Th[a]	4.6E+00	1.1
Ti[b]	5.2E+00	0.3
Tl[b]	6.8E+00	1
Tm[c]	3.2E+00	1.1
U[b]	0.0E+00	2.5
V[b]	4.6E+00	0.6
W[a]	2.3E+00	1.1
Y[a]	3.4E+00	0.9
Yb[c]	5.3E+00	1.1
Zn[b]	8.1E+00	1.1
Zr[b]	3.1E+00	0.9

[a] Bioaccumulation factor value is from Staven et al. (2003).
[b] Bioaccumulation factor distribution is from IAEA (2010a).
[c] Bioaccumulation factor value is from NCRP (1996).
Sources: IAEA (2010a), Staven et al. (2003), and NCRP (1996) as noted.
Note: μ = mean of the underlying normal distribution, and σ = standard deviation of the underlying normal distribution.

C.6.10 Aquatic Food Contaminated Fraction

Applicable Code: RESRAD-ONSITE, RESRAD-OFFSITE

Description: The aquatic food contaminated fraction is the fraction of aquatic foods that are consumed from the site that are contaminated.

Units: no units

Probabilistic Input:

Distribution: triangular

Defining values for distribution:

Minimum: 0 Maximum: 1 Most likely: 0.39

Discussion: The aquatic foods contaminated fraction can range from 0 (none of the seafood products consumed are contaminated) to 1 (all seafood products consumed are contaminated). The balance of the aquatic foods (1—aquatic food contamination fraction) is assumed to come from uncontaminated sources. The parameter is dependent on whether there is an on-site pond capable of producing seafood products, as well as dietary and other habits of the individual being modeled. The aquatic food contamination fraction is required by the RESRAD-ONSITE and RESRAD-OFFSITE computer codes when the seafood ingestion pathway is active (Yu et al., 2001).

One measure of this parameter is the percentage of the annual seafood consumption rate from home-caught fish and shellfish. The EPA published the Exposure Factor Handbook (EPA, 1997) in part to summarize data on human behaviors and recommend values to use to model those activities. The consumption rates for home-consumed seafood products provided in the handbook were obtained from the USDA's National Food Consumption Survey (NFCS; USDA, 1980, 1992). Data from the 1987–1988 NFCS study were used to generate the homegrown intake rates. These intake rates vary by age, season, and geographic location. Among members of fishing households, home-caught fish accounted for 38 percent of the total fish consumption for the year (EPA, 1997).

A triangular distribution, as displayed in Figure C-57, is recommended for the aquatic food contamination fraction. Since the limits of the parameter can range from 0 (no aquatic foods consumed are contaminated) to 1 (all aquatic foods consumed are contaminated), these values were chosen for the upper and lower bounds of the distribution. A most likely value of 0.39 was chosen on the basis of the recreational fishing habits and consumption rates provided in the Exposure Factor Handbook (EPA, 1997).

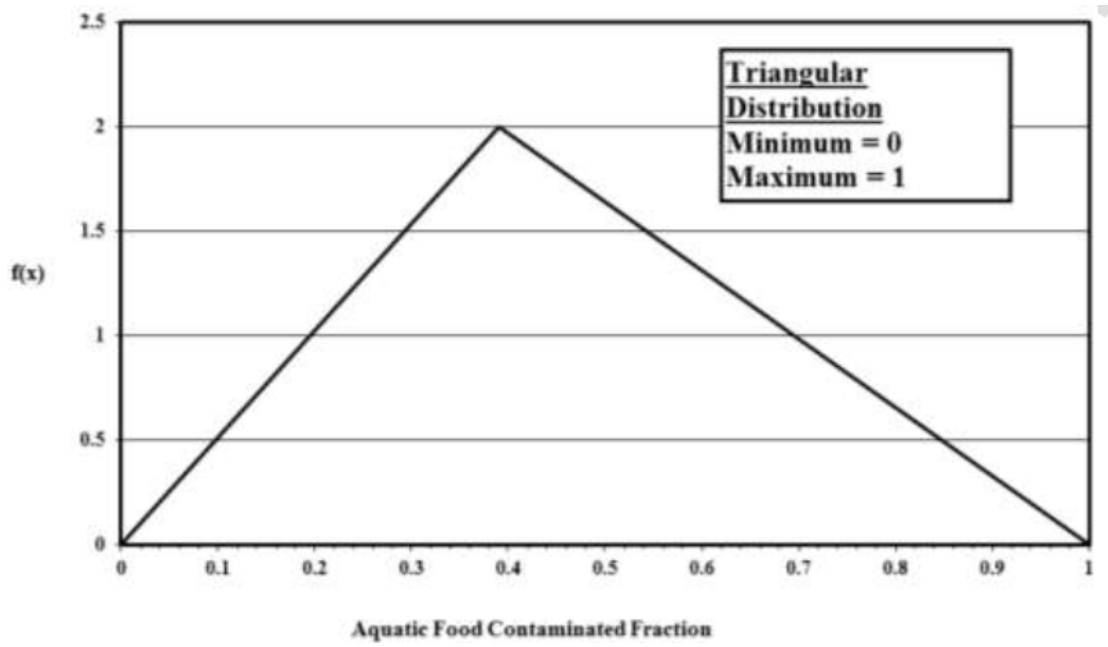

Figure C-57 Aquatic Food Contaminated Fraction Probability Density Function

C.7 <u>Building Characteristics</u>

C.7.1 Indoor Dust Filtration Factor

Applicable Code: RESRAD-ONSITE, RESRAD-OFFSITE

Description: The indoor dust filtration factor represents the fraction of outdoor contaminated dust that is available indoors.

Units: no units

Probabilistic Input:

Distribution: uniform

Defining values for distribution:

Minimum: 0.15 Maximum: 0.95

Discussion: The indoor dust filtration factor, the ratio of the long-term indoor-to-outdoor air concentrations of particulates, provides a measure of a building's effectiveness at removing particulate contaminants from the outdoor air that enters the building. This parameter is sometimes referred to as an inhalation shielding factor or a dose reduction factor when applied to inhalation exposures. The contribution of outdoor air to indoor particulate levels is primarily a function of a building's ventilation rate (including infiltration) and the indoor deposition velocity of the particulates.

As further discussed in Section C.7.4, the ventilation rate of buildings depends on the climate and season. For example, aside from mechanical ventilation, infiltration of outdoor air depends on temperature, wind speed, and quality of building construction. Earlier investigations found indoor/outdoor air concentration ratios for different building types ranging from close to 0 up to 1 (see Table C-85). Even for office or industrial building types, with the mechanical ventilation systems turned off, air exchange can still be significant, and estimates of the indoor/outdoor air concentrations ratios could range above 0.1 when all outdoor entrances are closed (Engelmann, 1992).

It is believed that particulates of less than 10 µm in aerodynamic diameter are able to enter buildings with the same efficiency as nonreactive gases (Wallace, 1996). However, larger contaminant particles will deposit faster than smaller particulates, posing less of a radiological inhalation risk (Fogh et al., 1997).

A comprehensive review by Wallace (1996) indicates that numerous studies show indoor particulate concentrations can exceed outdoor concentrations because of indoor sources. When only considering outdoor sources, mean values are expected to be close to 0.5. Table C-86 lists estimates of the indoor/outdoor ratio made by Wallace (1996) based on the results of the EPA's Particle Team (PTEAM) study of residential housing. An average value of approximately 0.57 was found for PM_{10}, which is between the values estimated for the fine particle fraction ($PM_{2.5}$) and the coarse particle fraction (difference of PM_{10} and $PM_{2.5}$), 0.67 and 0.48, respectively. These values were derived with the assumption of decay rates of 0.39, 0.65, and 1.01 h^{-1} for fine particles, PM_{10} and the coarse particles, respectively, with the decay rate given by:

$$k = \frac{k_d S}{V} \tag{C-25}$$

where

K_d =deposition velocity,

S =interior surface area, and

V =interior volume

The indoor/outdoor ratios were estimated using these decay rates and average air exchange rates from the PTEAM study using the relationship:

$$\frac{C_{in}}{C_{out}} = \frac{P\,a}{a + k} \tag{C-26}$$

where

C_{in}=indoor particulate concentrations,

$Cout$ =outdoor particulate concentrations,

P =the penetration factor (set equal to 1), and

a=the building air exchange rate (h^{-1}).

If the average air exchange rate found in Murray and Burmaster (1995) for residential housing (0.76 h^{-1}), is used in the above relationship, the estimated indoor/outdoor ratio for PM_{10} would be 0.54, in good agreement with the values of 0.58 and 0.55 for daytime and overnight conditions, respectively, as presented in Table C-86

Limited measurement data are available for occupational settings. Table C-85 shows the possibility of a fairly wide range. As discussed further in Section C.7.4, a wide range of air exchange rates, and therefore, a wide range in indoor/outdoor concentration ratios, is expected for commercial buildings. Except for isolated instances (e.g., electronic manufacturing “clean” rooms) or shipping/receiving intensive enterprises, indoor/outdoor concentration ratios for residential settings are not expected to differ greatly, on average, from light industrial environments because the ratios depend on air exchange rates, and human comfort depends (in part) on air exchange rates. Because the air exchange rates can vary considerably with climate and season, as well as the difference attributable to particle size and occupational setting, it is not reasonable to assign a most likely value to the indoor dust filtration factor (indoor/outdoor air dust concentration ratio). Thus, a uniform distribution is selected for a generic setting, with minimum and maximum values of 0.15 and 0.95 as suggested by the results in Table C-86. The probability density function is shown in Figure C-58.

Table C-85 Indoor/Outdoor Air Concentration Ratio

Pollutant	Structure	Measured Indoor/Outdoor Ratio	Reference
Total suspended particulates	Homes and public buildings	0.16–0.51	Yocum et al., 1971
0.1–20 μm dust particulates	Old/new homes/university buildings	< 0.1–0.42	Alzona et al., 1979
Ca, Fe, Zn, Pb, Br	Homes and public and commercial buildings	0.043–0.85 (excluding Zn)	Cohen and Cohen, 1979
Particulates, iodine, noble gases	Wood or concrete construction	Calculated DRFs of 0.072–1	Kocher, 1980
Be-7	Danish and Finnish homes	0.23–0.86	Christensen and Mustonen, 1987
Various radioisotopes	Danish home	0.1–0.5	Roed and Cannell, 1987
Noble gases, methyl iodide, elemental iodine, aerosols 0.1–2 μm	Homes, large buildings, manufacturing facilities	Calculated DRFs of 0.004–1	Bank and De Witt, 1987

Table C-86 Fraction of Outdoor Particulates Found Indoors at Equilibrium (results from the PTEAM Study)

Statistic	Daytime (sample size = 174)			Overnight (sample size = 175)		
	Fine	PM10	Coarse	Fine	PM10	Coarse
Mean	0.68	0.58	0.49	0.66	0.55	0.46
Standard deviation	0.17	0.19	0.2	0.15	0.17	0.17
Standard error	0.013	0.015	0.015	0.012	0.013	0.013
Geometric mean	0.66	0.55	0.45	0.64	0.53	0.42
Minimum	0.28	0.19	0.13	0.28	0.19	0.13
25th percentile	0.55	0.42	0.32	0.55	0.43	0.34
Median	0.7	0.58	0.47	0.66	0.54	0.43
75th percentile	0.83	0.75	0.65	0.79	0.69	0.59
Maximum	0.95	0.93	0.89	0.94	0.9	0.85

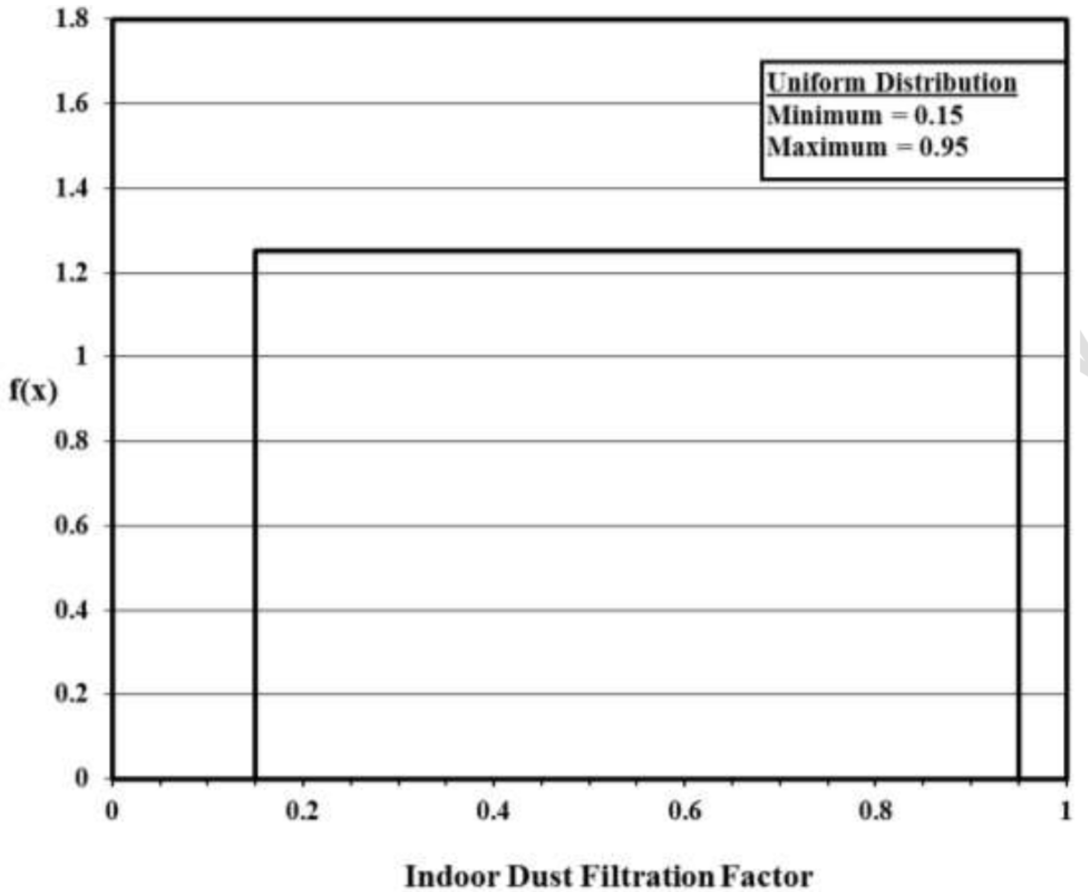

Figure C-58 Indoor Dust Filtration Factor Probability Density Function

C.7.2 Resuspension Rate

Applicable Code: RESRAD-BUILD

Description: The resuspension rate (indoor) represents the rate at which material deposited on interior surfaces is resuspended into the indoor air. Resuspension is the result of airflow or a mechanical disturbance, such as walking across a surface or sweeping.

Units: 1/s

Probabilistic Input:

Distribution: loguniform

Defining values for distribution:

Minimum: 2.5E-11 Maximum: 1.3E-05

Discussion: Indoor resuspension of contamination can lead to external exposure and internal exposure via inhalation. The resuspension rate is the fraction of deposited particles resuspended per unit time. Factors that can affect resuspension include the type of disturbance (airflow vs. mechanical), the intensity of the disturbance, the type of surface, particle size distribution, and physical and chemical characteristics of the particles.

Relatively little work has been conducted in measuring or estimating indoor resuspension rates. The most recent work by Thatcher and Layton (1995) monitored an sulfur hexafluoride (SF6) tracer in a residential setting under varying conditions. Table C-87 gives the results based on particle size. These results demonstrate that the larger particle sizes are more susceptible to resuspension. Other studies investigating the characteristics and dynamics of indoor dust behavior have shown that the primary source of larger particle sizes in indoor air is resuspension (Wallace et al. 1997; Vette et al. 2001). Thus, it is important to note, as has been done previously (Jones and Pond 1967), that a large fraction of resuspended material is non-respirable.

Non-respirable material is material that cannot be inhaled directly into the lungs. Larger particulates, greater than approximately 2.5 μm in diameter, cannot reach the deep respiratory tract where gas exchange occurs. This material becomes trapped in the nasal passages or upper respiratory tract, where it can dissolve and be absorbed into the blood or cleared by mechanical action (swallowing) into the gastrointestinal tract or exhaled. Current radiological inhalation dose conversion factors (e.g., those presented in Eckerman et al. 1999) are based on a particle size of approximately 1 μm in diameter. Risks from smaller or larger particles could be lower or higher, depending on the radionuclide and its speciation. Currently, not enough information is available to provide this type of radiological risk information on the basis of particle size. Neither is there enough information to provide estimates of resuspension rate according to particle size. Thus, the current resuspension rate model is particle size independent; however, the assigned distribution is influenced by the available data on varying particle sizes. The latest available resuspension rate information is discussed below.

Earlier studies of indoor resuspension of radioactive contamination reported the extent of resuspension in terms of a resuspension factor (Rf), that is, the ratio of airborne contamination to the amount deposited on surfaces. The following derivation provides an approximate conversion between the resuspension factor and the resuspension rate. When conservation of mass is assumed, the total change in the amount of airborne particulate material in a room [the left side of Equation (C-27)] is equal to an increase due to the amount resuspended, a decrease due to depositing material, and a decrease due to ventilation [terms 1–3, respectively, on the right side of Equation (C-27)].

$$V\frac{dC_A}{dt} = C_S \times A \times \lambda_r - C_A \times A \times u_d - C_A \times V \times n \tag{C-27}$$

where

C_A =contaminant air concentration,

C_S =contaminant surface concentration,

λ_r =resuspension rate,

V =A × H (the room volume),

A =contaminated surface area (assumed to be the floor where deposition occurs),

H =room height,

u_d =deposition velocity, and

n =number of air changes per unit time.

When both sides of the equation are divided by the room volume and when equilibrium conditions ($dC_A/dt = 0$) are assumed, the following is obtained:

$$C_S\frac{\lambda_r}{H} - C_A\frac{u_d}{H} - C_A \times n = 0 \tag{C-28}$$

Separation of the surface and air terms gives:

$$C_S\frac{\lambda_r}{H} = C_A\left[\frac{u_d}{H} + n\right] \tag{C-29}$$

The resuspension factor is the ratio of the air to surface concentration, as shown in Equation (C-30). From this, the relationship between the resuspension rate and the resuspension factor is derived [see Equation (C-31).]

$$R_f = \frac{C_A}{C_S} = \frac{\lambda_r}{u_d + n \times H} \tag{C-30}$$

$$\lambda_r = R_f(u_d + n \times H) \tag{C-31}$$

Table C-87 gives some indoor resuspension rates and the corresponding resuspension factors as determined by using Equation (C-31). Only those references with the additional requisite data (room height and air exchange rate) were used to estimate the resuspension rate from the resuspension factor. Because the deposition velocity was not measured in each case, the minimum and maximum values from the deposition velocity distribution (Section C.4.7) were used to provide a resuspension rate range for each resuspension factor. Data for the resuspension rates were provided in the case of Thatcher and Layton (1995), from which corresponding resuspension factors were derived by using deposition velocities supplied in that reference. Healy (1971) previously studied the correlation of the resuspension factor with the resuspension rate. Sansone (1987) and Beyeler et al. (1999) reviewed the earlier work in the context of resuspension factors rather than rates. Table C-88 summarizes previous work in the area of resuspension factors not addressed in Table C-87.

A number of factors (ventilation, physical activity/location, contaminated particle/floor characteristics, contamination source, and housekeeping practices) must be considered in selecting an appropriate distribution for the resuspension rate from the data discussed above. Many of the studies from which resuspension factors were derived or presented do not include enough information on room volume, contaminated surface area, and/or the ventilation rate in order to make a rough estimate of the resuspension rate by using the relationship in Equation (C.7.2-1). The magnitude of the resuspension factor, however, can be roughly correlated with the conditions under which it was obtained and can be compared with resuspension factors that have corresponding resuspension rates, as shown in Table C-87.

Ventilation rates in commercial buildings that might fall under the light industrial classification for the building scenario are expected to be near 1 air change per hour (see Section C.2.4). Those studies conducted with no ventilation are expected to overestimate the resuspension factor because some removal of the air contamination would occur under normal operating conditions. In contrast, those studies with excessive ventilation might underestimate the reported resuspension factor because more air contamination would be removed under these conditions than under normal operating conditions.

Physical activity is an important factor in the resuspension of particulate matter. A dramatic example was presented by Wallace et al. (1997), who monitored air particle concentrations during a study of an occupied townhouse. Coarse particle (5–10 μm) air concentrations were shown to be orders of magnitude higher during the periods of time that the occupants were not sleeping or away. Even working in front of a computer had a large impact on coarse particle (> 2.5 μm) resuspension (Wallace et al. 1997). Other studies have also indicated that a major source of larger particles (> 1.0 μm) in indoor air is resuspension (Vette et al. 2001). Thus, those resuspension factor studies with high levels of physical activity are not representative of what an average individual might experience in the course of a working day. At the other extreme, studies conducted with no physical activity are also non-representative and might underestimate the value of the resuspension factor.

The location of the surface-contaminated area(s) will affect the estimated resuspension factor and resuspension rate. Deposited material on the floor in a high-traffic area is much more likely to be resuspended than deposited material on equipment, walls, or seldom-traversed areas. The same is also true for “fixed” residual contamination in remediated areas. The larger the constantly disturbed area, the larger the resuspension factor. Thus, this consideration is closely allied with physical activity, as previously discussed.

The likelihood of particle resuspension is related to its adherence to the surface. Contamination remaining after remediation is expected to be relatively “fixed,” that is, hard to remove because it is tightly bound (e.g., chemically bonded) or deep within microscopic depressions of the surface. In the latter case, it is actually the result of the inability of mechanical action to contact the contamination when a rough surface is encountered. In contrast, deposited material is generally loosely bound and relatively easily resuspended. Thus, the primary source of the contamination (“fixed” or deposited) must also be taken into consideration when determining the resuspension factor or resuspension rate for use in risk assessment.

Normal housekeeping operations, such as dusting, sweeping, mopping, and vacuuming, in a light industrial environment will minimize potential risks to building occupants from resuspension of contaminated materials during normal working hours. Risks to the cleaning staff will be elevated, but only for short periods of time. These operations reduce the buildup of contaminated material from deposition and further reduce any residual “fixed” contamination. Thus, those buildings with more frequent cleaning schedules are expected to have lower resuspension factors/rates than those sporadically cleaned, because the more loosely bound material from deposition is maintained at lower levels.

The RESRAD-BUILD input parameters, such as the source lifetime, removable fraction, and air release fraction, are used to control the amount of contaminated material that becomes available within the building from residual contamination. In turn, the resuspension rate in RESRAD-BUILD must account for resuspension of the resultant deposited contamination. In DandD, however, the resuspension factor is the only input that accounts for airborne contamination and, therefore, must be more concerned with the source (residual contamination), which is not as easily removed as is deposited material. Thus, the input distribution in RESRAD-BUILD for the resuspension rate covers a wider range of equivalent values than the input distribution for the resuspension factor in the DandD code (McFadden et al. 2001). In the latter, values should be limited to “fixed” contamination in order to avoid violating the contamination mass balance and overestimating the inhalation exposure.

A loguniform distribution is suggested to represent the resuspension rate in RESRAD-BUILD because of the limited data available and the wide range of estimated values. The wide range in the estimated values can be attributed primarily to differences in particle size and indoor human activity levels. To represent an occupational setting, the lowest value involving any type of activity in Table C-87 was chosen, 2.5E-011 s^{-1}. Similarly, the largest value in Table C-87, 1.3E-05 s^{-1}, was chosen as the maximum value for the distribution. Figure C-59 shows the probability density function selected for the indoor resuspension rate.

Table C-87 Indoor Resuspension Rates

Resuspension Rate (1/s)[a]		Resuspension Factor (m^{-1})	Conditions	Reference	Comments
Minimum	Maximum				
7.7E-07	1.1E-06	1.2E-04	4–6 people walking	Brunskill (1967)	Change room, 1–3 percent removed by smears, 50 percent by water wash.
5.1E-10 1.1E-10 2.5E-10 1.9E-09	5.1E-07 1.1E-07 2.5E-08 1.9E-06	1.9E-04 3.9E-05 9.4E-06 7.1E-04	Vigorous work, including sweeping (ZnS) Vigorous walking (ZnS) Collecting contaminated samples (ZnS) Light sweeping with fans on for circulation (CuO)	Fish et al. (1967)	Measurements of ZnS and CuO tracers.
3.3E-08	2.2E-07	4.0E-06 to 2.0E-05	Pu	Ikezawa et al. (1980)	Cleanup following accidental failure of a Pu glove box.
1.9E-10 9.5E-08 4.8E-07 1.9E-10 9.5E-09 4.8E-08	2.5 E-10 1.2E-07 6.1E-07 2.5E-10 1.2E-08 6.1E-08	2 0E-08 1 0E-05 5 0E-05 2 0E-08 1 0E-06 5 0E-06	Plutonium oxide, no movement 14 steps/min 36 steps/min Plutonium nitrate, no movement 14 steps/min 36 steps/min	Jones and Pond (1967)	Contamination applied in solution and allowed to dry.

[a] Estimated from the resuspension factor using Equation C.7.2-5 and minimum and maximum values for the deposition velocity from Section J.2.2.

[b] Not applicable. Resuspension factors were estimated from resuspension rates for Thatcher and Layton (1995).

Table C-87 Indoor Resuspension Rates (cont.)

Resuspension Rate (1/s)[a]		Resuspension Factor (m^{-1})	Conditions	Reference	Comments
Minimum	Maximum				
4.2E-08 3.3E-08 3.7E-06 1.1E-05	4.8E-08 3.9E-08 4.3E-06 1.3E-05	2.5E-06 2.0E-06 2.2E-04 6.8E-04	Alpha, no work performed Beta, no work performed Alpha, floors scrubbed with cotton Beta, floors scrubbed with cotton	Khvostov and Kostiakov (1969)	Investigation of a "hot" laboratory.
2.4E-09	2.4E-06	9.0E-04	$Ba^{35}SO_4$	Shapiro (1970)	Membrane with $Ba^{35}SO_4$ ignited and combustion products deposited on floor; maximum value of subsequent measurements made while banging on floor.
1.4E-06 3.8E-07 3.2E-06 2.1E-06	2.0E-06 5.4E-07 4.5E-06 2.9E-04	2.2E-04 5.9E-05 4.9E-04 3.2E-05	Personal air samplers Area air samplers Personal air samplers Area air samplers	Tagg (1966)	100 steps/min, contaminated floor; 100 steps/min, contaminated clothing.
2.8E-10 1.2E-10 5.0E-09 2.3E-08 1.1E-07 9.4E-09	NA[b] NA[b] NA[b] NA[b] NA[b] NA[b]	1.4E-06 6.0E-07 9.4E-06 2.0E-05 6.1E-05 3.2E-06	0.3–0.5 μm particles 0.5–1 μm particles 1–5 μm particles 5–10 μm particles 10–25 μm particles > 25 μm particles	Thatcher and Layton (1995)	Estimated for residence with four residents performing "normal" activities. Assumed air exchange rate of 0.3 h 1.

[a] Estimated from the resuspension factor using Equation C.7.2-5 and minimum and maximum values for the deposition velocity from Section J.2.2.

[b] Not applicable. Resuspension factors were estimated from resuspension rates for Thatcher and Layton (1995).

Table C-88 Resuspension Factors from Previous Studies

Resuspension Factor (m^{-1})[a]	Conditions	Reference	Comments
 1.8E-06 4.3E-05	I-131 Active work in open space Active work in confined, unventilated space	Chamberlain and Stanbury (1951)	I-131 labeled brick and plaster dust (bulk of dust <1 μm), as reported in Sansone (1987).
2.5E-05 – 1.9E-04	UF_4 powder	Bailey and Rohr (1953)	Normal operations at a uranium processing plant.
1 0E-09 – 4.2E-06 7.0E-08 – 4.0E-05	Uranium, total surface activity using rate meter, larger if removable activity values used. Ra, total surface activity using rate meter, larger if removable activity values used.	Eisenbud et al. (1954)	Estimated from surface and airborne activity at 5 uranium processing plants. Estimated from surface and airborne activity at 10 radium plants
4.0E-05	"Dusty operations"	Barnes (1959)	As reported in McKenzie et al. (1998).
 5 0E-04 3 0E-05	U compounds 0.5-h samples 8-h samples	Becher (1959)	As reported in Sansone (1987). Wipes used to measure surface activity
 2.0E-06 – 5.9E-05 5.0E-05 – 14E-04	U Ore sampling plant Uranium reduction plant	Utnage (1959)	As reported in Sansone (1987).
 1.5E-02 5.0E-03 – 1.2E-02 7.9E-03 9.3E-03 2 0E-02	Be and compounds Loading/unloading Be blocks Cleaning Be blocks Be cyclotron target preparation Be compound synthesis Warehouse inventory	Hyatt et al. (1959)	Resuspension factor as estimated by Sansone (1987). Surface contamination measured by wipe; maximum values for wipe and air concentration used.
 4.0E-06 – 2.6E-04 8.0E-05 – 1.4E-03	U compounds 8-h air samples 10-min air samples	Schulz and Becher (1963)	As estimated by Sansone (1987), measurements from operating UF_6 manufacturing plant, surface contamination measured by wipes.
 1.0E-04 1.3E-04 1.45E-04 1.0E-04 1.35E-03 9.7E-03	U Undisturbed Fans on Fans on with movement Pu Undisturbed Fans on Fans on with movement	Glauberman et al. (1967)	As reported in Sansone(1987), operating uranium processing plant, abandoned precious metals. Recovery plant (Pu contamination), surface contamination measured with smears.
 4.2E-04 1.0E-02	Be Two men sweeping vigorously Sweeping after vacuuming	Mitchell and Eutsler (1967)	As reported in Sansone(1987). Unventilated storeroom with wood floor, smears used for surface contamination.
 <=1.7E-07 4.7–7.5E-06 <=0.7E-07 1.0–1.7E-05	UO2 In ethanol, undisturbed In ethanol, 60 steps/min Powder, undisturbed Powder, 60 steps/min	Cortissone et al. (1968)	As reported in Sansone (1987).
 1.2–5.3E-03 2.0–4.2E-03	Chrysotile Contaminated lab coat handling contaminated materials	Carter (1970)	As reported in Sansone (1987), surface contamination measured by vacuuming.
1.2E-04 3.3E-04	Sr applied in solution Co applied in solution	Gorodinsky et al. (1972)	As reported in Sansone (1987), after 1 h in wind tunnel; steel, painted steel, stainless steel, vinyl plastic, and organic glass surfaces had essentially the same results.

Table C-88 Resuspension Factors from Previous Studies (cont.)

Resuspension Factor (m^{-1})[a]	Conditions	Reference	Comments
 0.2–13E-06 0.01–1.5E-06 0.3–10E-06 0.08–1.5E-06	Be (aqueous suspension applied) Fan on Fan off Ammonium fluoroberyllate (aqueous solution applied) Fan on Fan off	Kovygin (1974)	As reported in Sansone (1987). From polyvinyl chloride surface, 1.8 m/s airflow with fan on.
4 0E-05	Pu under unspecified conditions	Wrixon et al. (1979)	As estimated in Sansone (1987), using data from the reference.
5.7E-04	Workplace for I-125 immunoassay studies	Dunn and Dunscombe (1981)	Surface contamination measured using wipes with 70 percent isopropyl alcohol.
5.5E-08 to 1.1E-07	Radioactive particulates	Ruhter and Zurliene (1988)	Activity in Three Mile Island auxiliary building during cleanup after accident.
4.25E-07 7.79E-06 8.97E-07	U; surface contamination measured using wipes, three 1-year averages	Spangler (1998)	U storage area at operating uranium fuel fabrication plant.
1.7E-07 4.2E-08	Primarily Co-60 and Cs-137 during decommissioning shutdown mode	Nardi (1999)	No forced air ventilation, measurements at a "pump repair" facility.

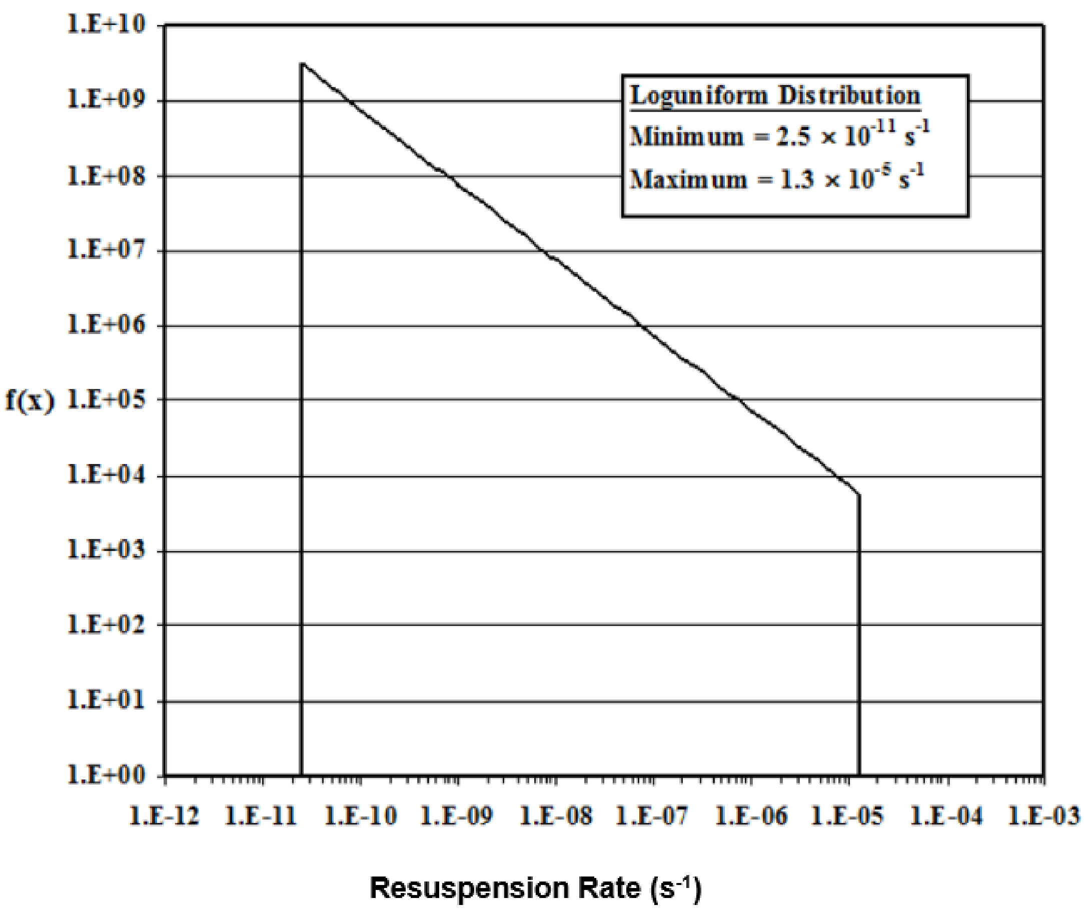

Figure C-59 Indoor Resuspension Rate Probability Density Function

C.7.3 Shielding Density

Applicable Code: RESRAD-BUILD

Description: This parameter represents the effective density of shielding between a receptor and a radiation source.

Units: grams per cubic centimeter (g/cm3)

Probabilistic Input: (allowed only for concrete):

Distribution: uniform

Defining values for distribution:

Minimum: 2.2 Maximum: 2.6

Discussion: The type of shielding material, along with the shielding thickness and density, determines the gamma attenuation properties of the shield. This parameter is important for the external exposure pathway. For situations in which only air is between the source and receptor, the shielding thickness should be set to 0 and the density becomes immaterial. The type of shielding material will often determine the density.

In the RESRAD-BUILD code, the user must input the shielding characteristics for each source-receptor pair (e.g., if there are 4 sources and 6 receptors, the code would require 24 shielding characteristics). RESRAD-BUILD accommodates eight types of shielding materials: concrete, water, aluminum, iron, lead, copper, tungsten, and uranium. Table C.7-89 gives the density range (if appropriate) and a single value of density for the RESRAD-BUILD shielding materials that have a narrow range (except concrete). The table lists ranges for cast iron and gives a single-value density for other materials. The values are taken from The Health Physics and Radiological Health Handbook (Shleien 1992) and from the CRC Handbook of Chemistry and Physics (Lide 1998). Table C-90 provides the concrete density from three different sources: The Health Physics and Radiological Health Handbook (Shleien 1992), Properties of Concrete (Neville 1996), and Standard Handbook for Civil Engineers (Merritt et al. 1995). The value used in the code is for ordinary concrete. If the type of concrete is known, a uniform distribution between the given range for a known concrete type can be used. The probability density function for concrete shielding density is displayed in Figure C-60.

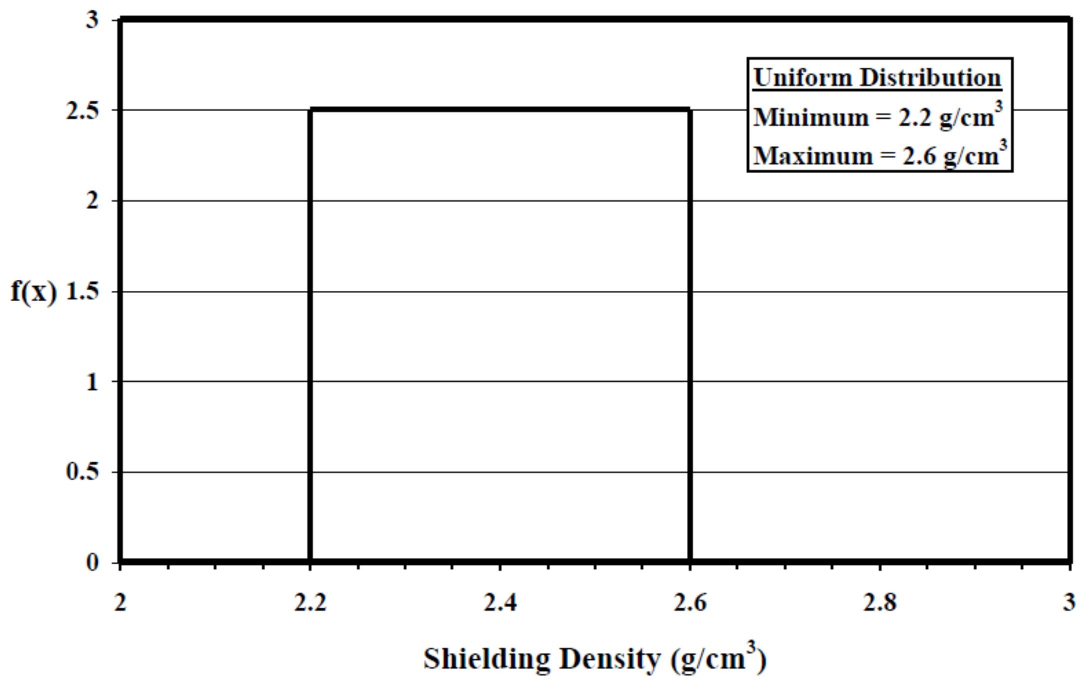

Figure C-60 Concrete Shielding Density Probability Density Function

Table C-89 Density of Shielding Materials (except concrete) Allowed in RESRAD-BUILD

Material	Density Range (g/cm^3)	Normal Density (g/cm^3)
Aluminum	-[a]	2.7
Copper	-	8.96
Lead	-	11.35
Steel	-	7.8
Cast iron	7.0–7.4	
Water	-	1.0
Tungsten	-	19.3
Uranium	-	19.1
Iron	-	7.87

[a] A dash indicates that data were not available.
Sources: Shleien (1992); Lide (1998).

Table C-90 Shielding (Concrete) Density from Various Sources

Aggregate	Concrete Density (g/cm^3)		
	Shleien (1992)	Neville (1996)	Merritt et al. (1995)
Ordinary (silicacious) or normal weight	2.2–2.4	2.2–2.6	2.3
Heavy weight	-[a]	-	2.4–6.15
Limonite (goethite, hyd. Fe_2O_3)	2.6–3.7	-	-
Ilmenite (nat. $FeTiO_3$)	2.9–3.9	-	-
Magnetite (nat. Fe_3O_4)	2.9–4.0	-	-
Limonite and magnetite	-	-	3.35–3.59
Iron (shot, punchings, etc.) or steel	4.0–6.0	-	4.0–4.61
Barite	3.0–3.8	-	3.72
Lightweight	-	0.3–1.85	0.55–1.85
Pumice	-	0.8–1.8	1.45–1.6
Scoria	-	1.0–1.85	1.45–1.75
Expanded clay and shale	-	1.4–1.8	-
Vermiculite	-	0.3–0.8	0.55–1.2
Perlite	-	0.4–1.0	0.8–1.3
Clinker	-	1.1–1.4	-
Cinders without sand	-	-	1.36
Cinders with sand	-	-	1.75–1.85
Shale or clay	-	-	1.45–1.75
Cellular	-	0.36–1.5.	-
No-fines	-	1.6–2.0	1.68–1.8
No-fines with lightweight aggregate	-	0.64–higher	-
Nailing	-	0.65–1.6	-
Foam	-	-	0.3–1.75

[a] A dash indicates that data were not available.

C.7.4 Air Exchange Rate for Building and Room

Applicable Code: RESRAD-ONSITE, RESRAD-OFFSITE, RESRAD-BUILD

Description: The air exchange (or ventilation) rate for a building or a room is the total volume of air in the building or room replaced by outside air per unit of time.

Units: 1/h

Probabilistic Input:

Distribution: truncated lognormal-n

Defining values for distribution:

Underlying mean value: 0.4187 Lower quantile value: 0.001

Standard deviation: 0.88 Upper quantile value: 0.999

Discussion: The building air exchange rate is input by the user for a one-room building. It is computed by using the heights and the areas of the rooms and by using the airflow rates into and out of the rooms for two-or three-room buildings. In RESRAD-BUILD, the building is conceptualized as a structure composed of up to three rooms. Air exchange is assumed between rooms 1 and 2, and rooms 2 and 3, but not between rooms 1 and 3. All rooms can exchange air with the outdoor atmosphere. The air exchange rate parameter is used in the air quality model. For the one-room model, the air exchange rate for the building and that for the room are the same value; this value is an input required by the code. For the two-room and three-room models, inflow from outside and the flow between the rooms are required. The room air exchange rate for two- or three-room buildings is computed by using the height and the area of the room and the airflow rates into and out of the room. The room air exchange rate strongly depends on the number of rooms, inflow, outflow, and net flow within the rooms. The full flow of air can be calculated only if the parameters satisfy certain conditions that guarantee a positive exchange of air between the rooms. In RESRAD-ONSITE and RESRAD-OFFSITE codes air exchange rate is used for radon inhalation pathway.

Air exchange involves three processes: (1) infiltration, which is air leakage through random cracks, interstices, and other unintentional openings in the building; (2) natural ventilation, which is airflow through open windows, doors, and other designed openings in the building; and (3) forced, or mechanical, ventilation, which is controlled air movement driven by fans.

The average infiltration rate for a building can be expressed as the number of air changes per hour or air exchange rate (h^{-1}). A single building can have a wide range of air exchange rates both in the short- and long-term, depending on environmental conditions at a particular time (e.g., seasonal/diurnal temperature, pressure, and ambient wind speed and direction); other factors include opening and closing of doors and windows, building type, construction, age, and ventilation system. A number of studies have attempted to characterize building air exchange rates under different environmental conditions for buildings with different leakage characteristics.

Measurement of the ventilation rate in a building (or room) can be accomplished directly by first injecting a tracer gas, SF_6, into the house and then, after a mixing time, using an infrared analyzer to measure the gas concentration as a function of time. The ventilation rate is equal to the rate of decay of the tracer concentration (Nero 1988).

A passive measurement technique that is available releases a gaseous tracer from a small source at a constant rate inside the building. A collector monitor, consisting of a diffusive tube and an absorber, measures the average concentration during the time the system is in operation. The measured concentration is proportional to the inverse of the ventilation rate. Further references for these ventilation rate measurement techniques, as well as some predictive quantitative models, can be found in Nazaroff et al. (1988), Nero (1988), and Sherman (1990).

The air exchange rate can be found by dividing the room air-volume exchange rate by the room volume. These parameters can be estimated if the building specifications are known (e.g., the air-volume exchange rate in a forced-air heating/cooling system can be estimated by multiplying the vent area and the velocity of forced air). The air exchange rate of the entire building is the total volume of air going out of the building per unit of time divided by the total volume of the building.

A comprehensive study of residential ventilation rates was published by Pandian et al. (1993). To evaluate the distribution of ventilation rates of a large population of homes in the United States, the researchers analyzed a Brookhaven National Laboratory (BNL) database consisting of more than 4,000 residential perfluorocarbon tracer (PFT) measurements from approximately 100 individual studies. Table C-91 presents summary statistics from that study on air exchange rates in the United States and regionally. Pandian et al. (1993) also analyzed the data by season and by the number of levels with the homes. They concluded that exchange rates are higher in the Southwest than in the Northeast and Northwest; summer ventilation rates are much higher than winter and fall rates; and multilevel residences have higher air exchange rates than single-level residences. The authors present both arithmetic and geometric means and standard deviations, as well as percentile distributions.

Murray and Burmaster (1995) also used the data compiled by BNL using the PFT technique to estimate univariate parametric probability distributions for air exchange rates for residential structures in the United States. The analysis was characterized by four key points: the use of data for 2,844 households; a four-region breakdown based on heating degree days; estimation of lognormal distributions as well as provision of empirical (frequency) distributions; and provision of these distributions for all of the data. The authors summarized distributions for subsets of the data defined by climate region and season. The coldest region (region 1) was defined as having 7,000 or more heating degree days, the colder region (region 2) as having 5,500 to 6,999 degree days, the warmer region (region 3) as having 2,500 to 5,499 degree days, and the warmest region (region 4) as having fewer than 2,500 degree days. The months of December, January, and February were defined as season 1; March, April, and May as season 2; June, July, and August as season 3; and September, October, and November as season 4. The authors concluded that the air exchange rate was well fit by lognormal distributions for small samples sizes except in a few cases. The mean and standard deviations are listed in Table C.7-91. The authors recommended that the empirical or lognormal distribution may be used in indoor air models or as input variables for probabilistic health risk assessments.

In a study sponsored by the EPA (Koontz and Rector [1995]), a similar data set as analyzed by Murray and Burmaster (1995) was used. However, an effort was made to compensate for the nonrandom nature of the data by weighting results to account for each state's share of occupied housing units. As shown in Table C.7.4-1, the results of Murray and Burmaster (1995) are similar to those of Koontz and Rector (1995).

Air exchange rates from other representative residential studies are also summarized in Table C-91. The type of distribution can vary, depending on the type of study. For example, a survey of various housing types by Grimsrud et al. (1983) demonstrated that houses generally have air exchange rates that fall in a lognormal distribution between 0.1 and approximately 3 h^{-1}, with most clustered in the 0.25 to 0.75 range; however, some older ("leaky") houses, including low-income housing, had infiltration rates exceeding 3 h^{-1}. In contrast, Lipschutz et al. (1981) obtained measurements of air infiltration into 12 energy-efficient houses in Oregon by using a tracer gas decay analysis. A narrow range of values was found (0.08–0.27 h^{-1}), reflecting the extremely "tight" building construction and ventilation systems installed in the houses.

Doyle et al. (1984) measured air exchange rates in 58 weatherized houses during a 4- to 5-month period during both winter and summer sampling periods. The houses were located in Fargo, North Dakota; Colorado Springs, Colorado; Portland, Maine; and Charleston, North Carolina. The investigators determined the geometric means and geometric standard deviations for air exchange rates for each city and for the entire sample. Because of the relatively small number of measurements in each city, conclusions about the geographic distribution of air exchange rates are limited. However, combining the data for the cities provides an overall lognormal distribution of 0.8 ± 1.8 h^{-1} (ranging from 0.2–2.3 h^{-1}), which appears to encompass most air exchange rates determined in other studies.

Studies on the air exchange rates of large commercial buildings have been much more limited. Table C-92 lists results from some studies on commercial buildings. It can be seen that these values are relatively close to those for residential construction. Although the primary outside air source for large buildings is the mechanical ventilation system, infiltration is the primary outside air source for residential homes (American Society of Heating, Refrigeration, and Air-Conditioning Engineers [ASHRAE] 1997). In either case, a continuous supply of outside air is required to dilute and eventually remove indoor contaminants. Thus, the air exchange requirements are expected to be similar for both residential and commercial construction. However, differences in local airflow and temperature, as well as air exchange, may be required to maintain workers' comfort according to their activity level.

Turk et al. (1987) examined the outdoor exchange rates of 38 buildings in the Pacific Northwest. The buildings included schools, libraries, and office buildings in mild and harsh climates measured during different seasons of the year. Results are shown in Table C-92. The arithmetic mean and standard deviation are 1.52 h^{-1} and 0.873, respectively. Although this set of data is limited, the mean falls between the arithmetic means determined Pandian et al. (1993) and Murray and Burmaster (1995), 1.99 and 0.76 h-1, respectively, for residential air exchange rates. The air exchange data from Persily and Grot (1985) and Silberstein and Grot (1985), as shown in Table C-92, fall within the range observed by Turk et al. (1987). The studies by Weschler et al. (1994), Dietz and Goodrich (1995), and Fisk et al. (2000) also fall within the same range. The study of a laboratory/office complex by Weschler et al. (1989) has two values outside this range, 4.0 and 8.2 h^{-1}. However, maximum values of 11.77 and 45.6 h^{-1} were used by Murray and Burmaster (1995) and Pandian et al. (1993), respectively.

While the data on commercial building air exchange rates are limited, the distribution of rates is expected, in part because of human comfort considerations, to be similar to residential structures when averaged over the United States for all four seasons of the year. Thus, a generic lognormal distribution has been assigned to the building exchange rate to represent average over all conditions. The mean and standard deviation of the distribution are those obtained by Turk et al. (1987), 1.52 h^{-1} and 0.88, respectively. As discussed above, the mean falls within the average mean found by different residential studies and is consistent with other commercial building studies. The standard deviation is the same as observed by Murray and Burmaster (1995). Because of the limited data set and variations across different industries, climates, and seasons, this distribution is only an approximation to potential building air exchange rates for light industry. Figure C-61 displays the probability density function for the building air exchange rate. The same lognormal distribution is assigned to room exchange rates because the building air exchange rate is an average of the rooms within.

Table C-91 Residential Air Exchange Rate (h^{-1}) Distribution Characteristics

Distribution Type	Min.	Max.	Mean	SD	Comments	References
Lognormal	0.3 0.2 0.3 0.7 0.2	2.2 2.3 2.2 1.4 2.3	0.9 0.6 0.5 1.0 0.8	1.8 1.8 2.1 1.3 1.8	Charleston, S.C. (*n* = 20 houses) Colorado Springs, Colo. (*n* = 16 houses) Fargo, N.D. (*n* = 11 houses) Portland, Maine (*n* = 11 houses) All cities (*n* = 58 houses) Calculated infiltration rates based on post-weatherization measurements of "effective leakage area."	Doyle et al. 1984
Normal	0.36 0.18 0.22 0.10	0.71 0.56 0.69 0.33	0.62 0.33 0.49 0.20	0.25 0.14 0.11 0.08	Pre-retrofit in one house: *n* = 17 measurements with fan on *n* = 11 measurements with fan off Post-retrofit in one house: *n* = 16 measurements with fan on *n* = 11 measurements with fan off	Berk et al. 1981
Normal	0.08	0.27	0.17	0.06	*n* = 12 energy-efficient houses	Lipschutz et al. 1981
Lognormal	0.1 0.1	3.1 3.6	0.5 median 0.9 median		*n* = 312 houses in North America Subsample of low-income housing	Grimsrud et al. 1983, as cited in Godish 1989
Lognormal	0.17 0.18	1.33 1.45	0.33 median 0.36 median		*N* = 8 mobile home measurements *n* = 10 UFF-insulated home measurements	Godish and Rouch 1988
Normal	0.22 0.47	0.50 0.78	0.35 0.63	0.08 0.10	*n*= 9 houses in upstate New York With mechanical ventilation off With mechanical ventilation on	Offermann et al. 1985
Normal	0.40 0.23	0.98 1.00	0.27 0.30		n = 10 houses in Washington state Pre-weatherization retrofit Post-weatherization retrofit	Lamb et al. 1985
Lognormal						
			0.89	3.44	All regions (*n* = 1,836) geometric mean, SD	Pandian et al. 1993
			0.34	1.88	Northwest (*n* = 423)	
			0.40	2.07	Northeast (*n* = 423)	

Table C-91 Residential Air Exchange Rate (h^{-1}) Distribution Characteristics (cont.)

Distribution Type	Min.	Max.	Mean	SD	Comments	References
Lognormal						
			1.86	3.02	Southwest (*n* = 990)	
			1.99	3.28	All regions (*n* = 1,836) arithmetic mean, SD	
			0.42	0.33	Northwest (*n* = 423)	
			0.60	2.23	Northeast (*n* = 423)	
			3.25	3.79	Southwest (*n* = 990)	
			0.76	0.88	All regions All seasons (*n* = 2844)	Murray and Burmaster 1995
			0.55	0.47	All regions Season 1 (*n* = 1139)	
			0.65	0.57	All regions Season 2 (*n* = 1051) arithmetic mean, SD	
			1.50	1.53	All regions Season 3 (*n* = 529)	
			0.41	0.58	All regions Season 4 (*n* = 125)	
			0.40	0.30	Region 1 All seasons (*n* = 467)	
			0.55	0.48	Region 2 All seasons (*n* = 496)	
			0.55	0.42	Region 3 All seasons (*n* = 332)	
			0.98	1.09	Region 4 All seasons (*n* = 1,549)	
			0.66	0.87	West Region (arithmetic mean and SD)	
			0.57	0.63	North Central Region	Koontz and Rector 1995
			0.71	0.60	Northeast Region	
			0.61	0.51	South Region	
			0.63	0.65	All	
			0.47	2.11	West Region (geometric mean and SD)	
			0.39	2.36	North Central Region	
			0.54	2.14	Northeast Region	
			0.46	2.28	South Region	
			0.46	2.25	All	

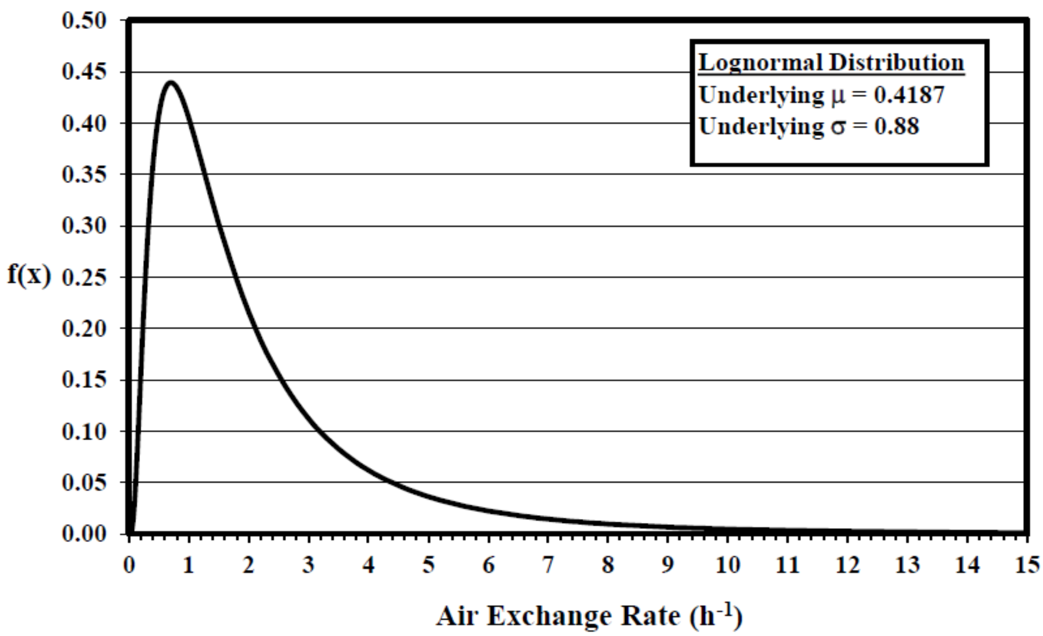

Figure C-61 Building Air Exchange Rate Probability Density Function

Table C-92 Outside Air Exchange Rates for Commercial Buildings

Building Air Exchange Rate (h^{-1})	Building Description	Reference
0.33–1.04	Large office buildings	Persily and Grot (1985)
0.9	The National Archive Building	Silberstein and Grot (1985)
	38 commercial buildings studied in the Pacific Northwest during all seasons of the year. Two buildings were sampled twice at different times of the year.	Turk et al. (1987)
	Number of buildings:	
0.0–0.5	3	
0.5–1.0	10	
1.0–1.5	9	
1.5–2.0	8	
2.0–2.5	6	
2.5–3.0	2	
3.0–3.5	0	
3.5–4.0	1	
4.0–4.5	1	
0.6, 4.0, and 8.2	Three buildings in an office/laboratory complex	Weschler et al. (1989)
0.3 – 1.9	1st floor of Burbank, California, office building over a 14-month period	Weschler et al. (1994)
2.5	Classroom building on a college campus	Dietz and Goodrich (1995)
0.45 – 0.53 and 0.68 – 0.74	Two different floors, each with its own air handling unit, in the same office building. Range of air exchanges observed over a 7-week period.	Fisk et al. (2000)

C.7.5 Room Area

Applicable Code: RESRAD-BUILD

Description: This parameter represents the floor area of a specific room in the building.

Units: square meters (m^2)

Probabilistic Input:

Distribution: triangular

Defining values for distribution:

Minimum: 3Maximum: 900 Most likely: 36

Discussion: The room area is used in determining the mixing volume of each distinct airflow volume (room) and the equilibrium of resuspension and deposition. It is used in conjunction with the height of the room and the airflow rates to compute the building air exchange rate and the room air exchange rate. By its nature, the airflow volume could represent the space within a small storage area (e.g., about 1 m^2) or a warehouse (e.g., thousands of m^2). The area is set for each defined room in the analysis and should be consistent with the definition of that room.

Studies concerning room size distribution are not available. An arbitrary distribution has been selected as a default for use in application of RESRAD-BUILD to commercial buildings. Site-specific distributions or deterministic values should be used if available. A triangular distribution is used to represent the room area. A minimum value of 3 m^2 (approximate room dimensions of 1.5 × 2 m) was chosen to represent such areas as utility rooms or storage closets in a commercial environment. A maximum value of 900 m^2 (slightly less than 10,000 ft^2) was chosen to represent larger areas that would correspond to the area of rooms housing such functions as light industrial assembly lines, small to intermediate warehouse operations, or large assembly halls. However, office space is generally required in support of such larger operations. Such a requirement skews the room size distribution toward smaller room area, which suggests that a uniform distribution between the minimum and maximum areas is not appropriate. The choice of a most likely value for a triangular distribution was arbitrary and attempted to account for this observation. A most likely value of 36 m^2 (390 ft^2) was chosen. This value lies above what might be expected for the area for a single-occupant office room (approximately 12 m^2, 3 m × 4 m) and is in the range of what might be expected for a multi-occupant office room. Figure C-62 presents the probability density function suggested for the room area.

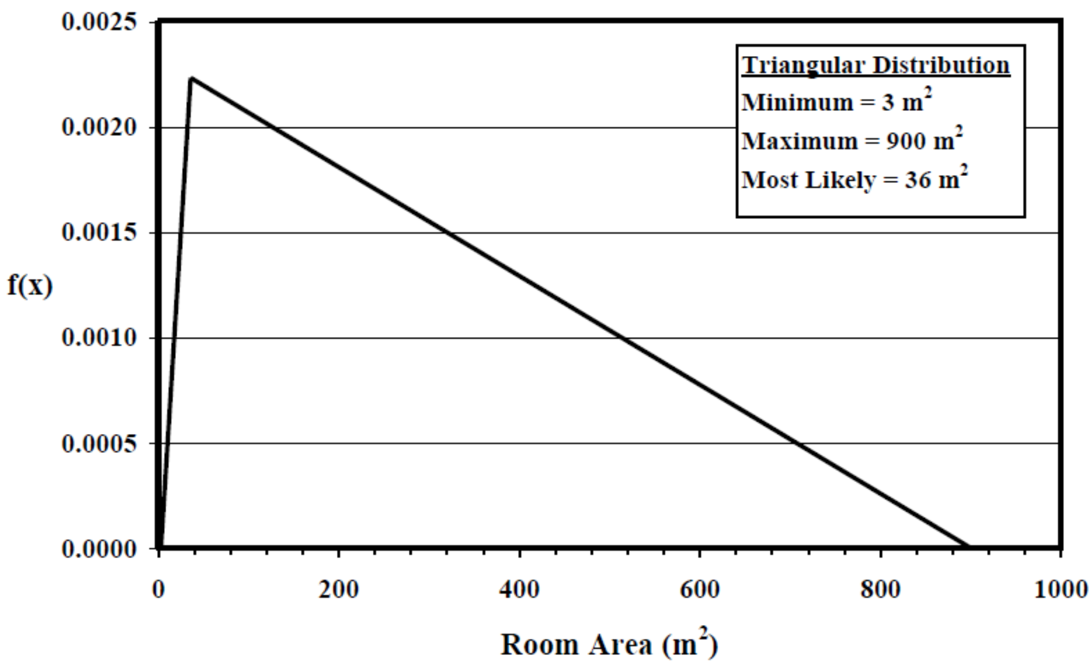

Figure C-62 Probability Density Function for Room Area

C.7.6 Room Height

Applicable Code: RESRAD-BUILD

Description: The room height is the distance between the floor and the ceiling of a specific room in the building.

Units: meters (m)

Probabilistic Input:

Distribution: triangular

Defining values for distribution:

Minimum: 2.4 Maximum: 9.1 Most likely: 3.7

Discussion: The room area is used in determining the mixing volume of each distinct airflow volume (room) and the equilibrium of resuspension and deposition. It is used in conjunction with the height of the room and the airflow rates to compute the building air exchange rate and the room air exchange rate. By its nature, the airflow volume could represent the space within a small storage area (e.g., about 1 m^2) or a warehouse (e.g., thousands of m^2). The area is set for each defined room in the analysis and should be consistent with the definition of that room.

Over half the new single-family homes constructed annually have room heights of 2.4 m (8 ft.), as shown in Table C-93. The 2.4-m (8-ft) height is considered to be typical of residential housing (EPA 1997). Minimum room heights of 2.1 m (7 ft.) below beams and girders are required by the Council of American Building Officials, with a ceiling height of not less than 2.3 m (7.5 ft.) for half of the required area (National Association of Home Builders [NAHB] 1998). The United States Department of Housing and Urban Development requires a minimum ceiling height of not less than 2.1 m (7 ft.) for at least half of the floor area and 1.9 m (6 ft. 4 in.) under ducts and beams.

No comprehensive study of room height in commercial buildings exists. Room height can vary within the same occupational setting as well as between industries. Room height may also vary according to climate (because of energy efficiency considerations). A typical room height in commercial buildings is 3.7 m (12 ft.; EPA 1997). A minimum of 2.4 m (8 ft.) is found in smaller rooms, such as those used for individual offices or conference rooms. Larger room heights are found in warehousing (shipping/receiving) operations, which may have room heights of up to approximately 9.1 m (30 ft.). Thus, for an occupational scenario, such as light industry, a default triangular distribution for the room height is suggested, with a most likely value of 3.7 m and minimum and maximum values of 2.4 and 9.1 m, respectively. This distribution is a rough generalization, and site-specific data should be used when available. The probability density function is shown in Figure C-63.

Table C-93 Room Height in New Conventional and Manufactured Homes, 1996

Room Height (m) [ft.]	Conventional Homes (First Floor), Percent of Total	Manufactured Homes, Percent of Total
≤ 2.1 [≤7]	0.1	48.2
2.3 [7.5]	1.6	37.4
2.4 [8.0]	57.8	5.1
2.6 [8.5]	0.8	1.5
2.7 [9.0]	24.2	7.7
> 2.7 [> 9]	15.5	<0.1
Source: NAHB (1998).		

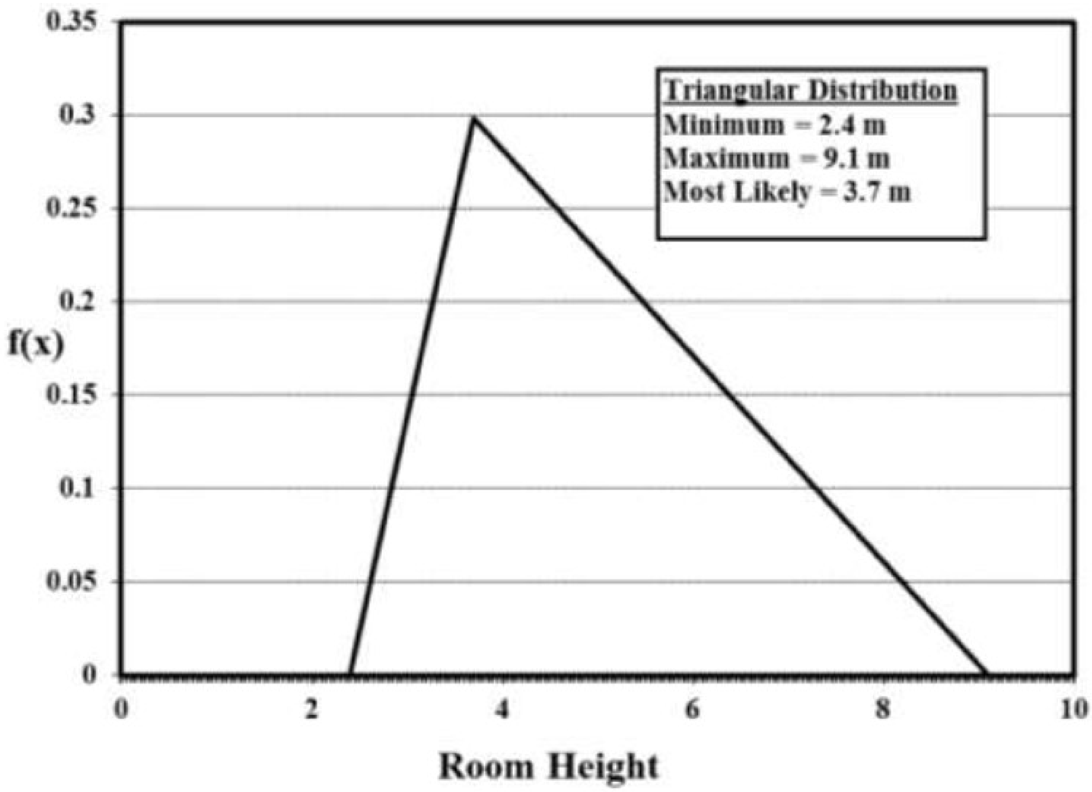

Figure C-63 Room Height Probability Density Function

C.7.7 Shielding Thickness

Applicable Code: RESRAD-BUILD

Description: This parameter represents the effective thickness of shielding between a source and receptor pair.

Units: centimeters (cm)

Probabilistic Input:

Distribution: triangular

Defining values for distribution:

Minimum: 0Maximum: 30 Most likely: 0

Discussion: The shielding thickness parameter is used in determining the attenuation of direct external radiation from each source to each receptor. Shielding thickness only affects the external exposure pathway. For situations where only air is present between the source and receptor, the shielding thickness is 0. The RESRAD-BUILD code requires the shielding thickness for every source and receptor pair (e.g., if there were 4 sources and 6 receptors, the code would require 24 [6 × 4] shielding thickness input values). The same shielding object might be assigned different thicknesses for different source-receptor pairs because of geometry considerations. It is highly recommended that the shielding thickness value be obtained from a direct measurement based on the site-specific condition. For example, to calculate dose for a receptor in a room other than the room in which the source is located, a shielding thickness equivalent to the wall thickness should be assumed.

Floor and wall thicknesses vary depending on the type of building and type of construction. To estimate the total contaminated volume of concrete from DOE facilities, Ayers et al. (1999) assumed an average concrete thickness of (30 cm (12 in.) in a building. For external exposure calculations, this thickness approximates an infinite thickness for alpha-emitters, beta- emitters, and X-ray or low-energy photon emitters. A shielding thickness of 30 cm would reduce the dose significantly from the external exposure pathway for all radionuclides, including high-energy gamma emitters.

Little information is available for the shielding thicknesses in actual D&D situations; therefore, a triangular distribution is assumed. The maximum value is assumed to be 30 cm, the minimum value is chosen as 0 cm, and the most likely value also is chosen to be 0 cm (this assumption would yield most conservative dose results for the external exposure pathway). The probability density function is shown in Figure C-64.

Since the attenuation of gamma radiation within a volume source is calculated separately, this parameter should account only for the thickness of shielding material external to the volume source. The user should ensure that the thickness entered does not exceed the distance between the source surface and the receptor.

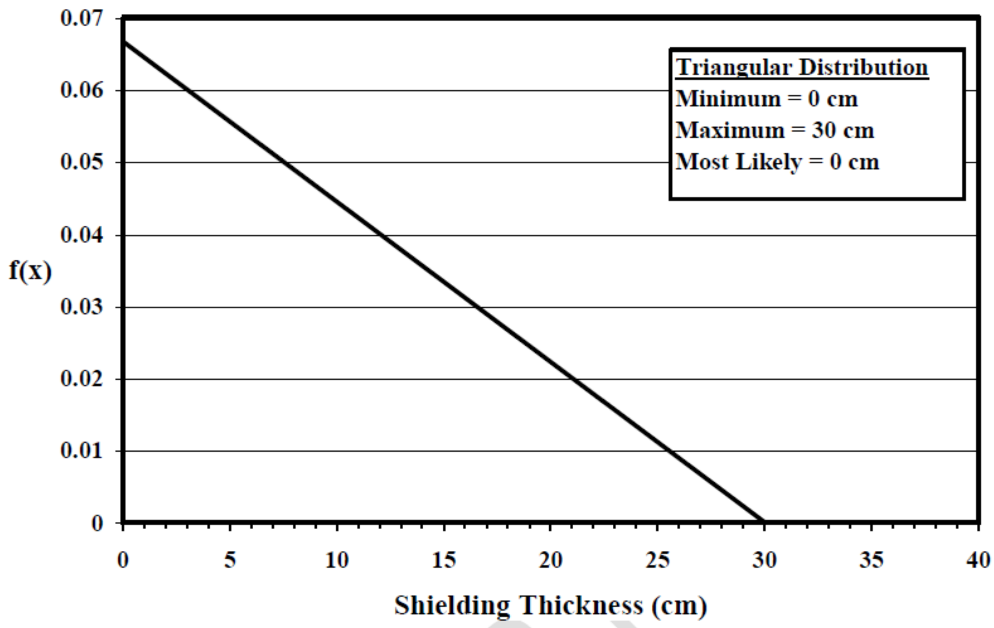

Figure C-64 Shielding Thickness Probability Density Function

C.7.8 External Gamma Shielding/Penetration Factor

Applicable Code: RESRAD-ONSITE, RESRAD-OFFSITE

Description: The shielding factor or penetration factor for external gamma radiation is the ratio of the external gamma radiation level indoors on-site to the radiation level outdoors on-site. It is a function of the shielding that building materials provide against the penetration of gamma radiation.

Units: no units

Probabilistic Input:

Distribution: bounded lognormal-n

Defining values for distribution:

Underlying mean value: -1.3 Lower limit: 0.044[4]

Underlying standard deviation: 0.59 Upper limit: 1

Discussion: A single external shielding factor is used to account for the attenuation of gamma radiation by building materials. The external shielding factor is the fraction of outdoor external gamma radiation level that is present indoors. The parameter can range from 0 (complete attenuation) to 1 (no attenuation).

Home construction type, as well as gamma energy has a dramatic effect on the attenuation of gamma radiation. Concrete and brick attenuate gamma radiationmore effectively than wood; hence, a house built on a concrete slab or built with a full basement will have a external shielding factor (i.e., will provide more protection) than a house built with a crawlspace without a finished concrete floor. Similarly a house that has exterior walls made of brick or stone will have a lower external shielding factor than a house with outer walls made of wood or other building materials.

Many recent studies have used the MCNP Monte Carlo radiation transport code to estimate the site-specific external shielding factor. Salinas et al. (2006) studied external gamma shielding factors for typical houses in Brazil from uniform deposited contamination on the ground, walls, and roof for three energies (300, 662, and 3000 keV). Barr et al. (2010) developed site-specific shielding factors for multiple building-source configurations for Th-232 decay chain radionuclides. Dickson and Hamby (2014) identified the general construction materials used in United States homes from the published Residential Energy Consumption Survey (RECS) data and provided the shielding protection factors for these construction materials.

Data obtained from the U.S. Census Bureau indicates that approximately 20 percent of the new homes constructed during the years 1993−1999[5] were built on a crawlspace (United States Department of Housing and Urban Development, 1996, 1999). Approximately 43 percent of homes constructed in the same period were built on a slab, and the remaining 37 percent of the homes were built either on a full or partial basement (U.S. Department of Housing and Urban Development, 1996, 1999). Data obtained from the same sources showed that 27 percent of the homes built in the United States between 1996 and1999 used brick or stone as the principal building material for the exterior walls. Approximately 56 percent of the homes constructed within the same period had primary exterior walls made of either wood or vinyl/aluminum siding, while the remaining 17 percent had exterior walls made of stucco (U.S. Department of Housing and Urban Development, 1999)

External shielding factors were estimated for five different radioisotopes—Cs-137, Co-60, Mn-54, U-238, and Ra-226—for four different home construction types. The types considered were (1) a brick home constructed over a full basement or on a slab, (2) a frame house constructed over a full basement or on a slab, (3) a frame house constructed with a crawlspace, and (4) a frame house constructed with a partial basement. The shielding factors were estimated with RESRAD-BUILD using five source geometries. The full basement/slab was modeled by placing a 15-cm (6-in.) concrete shield over the surface contamination, while the crawlspace was modeled by placing a 2.5-cm (1-in.) shield over the surface contamination. The brick and wooden walls were modeled using a 10-cm (4-in.) concrete and 2.5-cm (1-in.) wooden shield, respectively. It was assumed a person in the house spent 50 percent of the time completely shielded by the brick or wooden walls and 50 percent of the time by a window (essentially unshielded). The external shielding factors provided in Table C-94 for the scenarios listed above are average values for the radionuclides that were analyzed. The shielding factors presented in the table were found to be consistent with those obtained from previous studies (NRC, 1975; Jensen, 1983; Golikov et al., 1999).

The probability distribution for the external shielding factor was obtained by combining the results from the RESRAD-BUILD computer code with the data obtained from the U. S. Department of Housing and Urban Development (1996, 1999). The external shielding factor was assumed to be distributed lognormally, and Bayesian techniques were used to estimate the parameters of the distribution. The posterior means of μ and σ were used to characterize the probability distribution for the external shielding factor. The probability density function is shown in Figure C-65.

Table C-94 External Shielding Factors

Scenario	External Shielding Factor
Brick House Constructed with a Slab or Full Basement	0.17
Frame House Constructed with a Slab or Full Basement	0.21
Frame House Constructed with a Crawlspace	0.81
Frame House Constructed with a Partial Basement	0.51

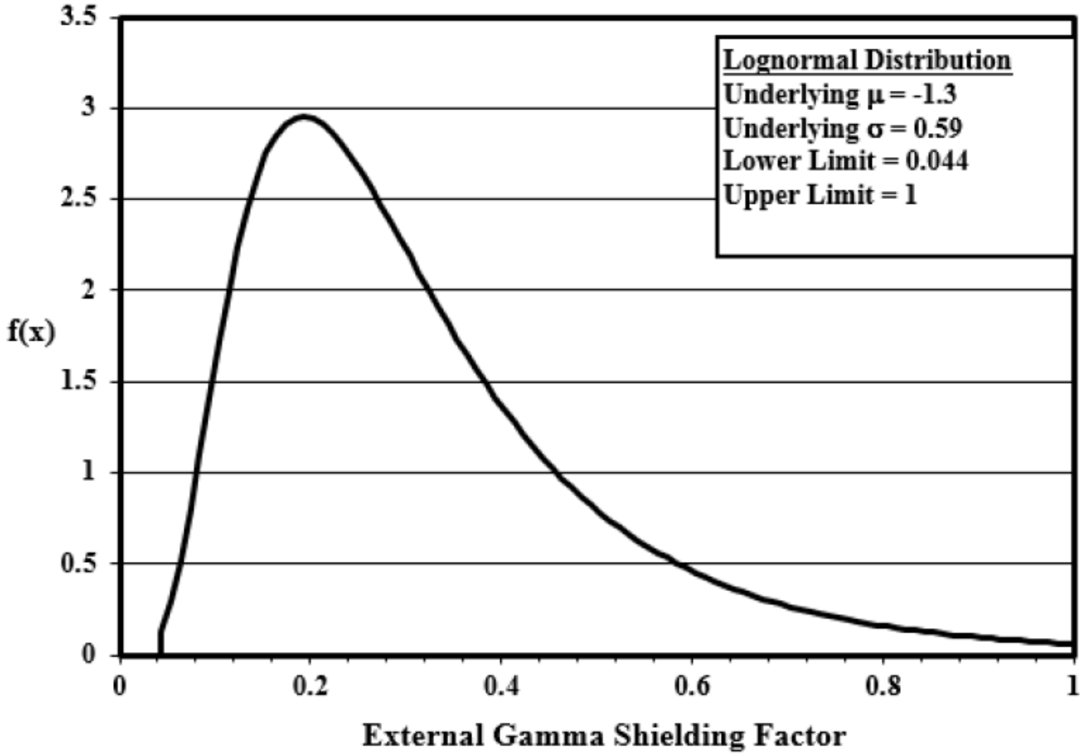

Figure C-65 External Gamma Shielding Factor Probability Density Function

C.8 Source Characteristics

C.8.1 Source Density, Volume Source

Applicable Code: RESRAD-BUILD

Description: The source density parameter represents the effective density of each cylindrical layer (region) in an idealized volume source.

Units: grams per cubic centimeter (g/cm^3)

Probabilistic Input: (allowed only for concrete):

Distribution: uniform

Defining values for distribution:

Minimum: 2.2 Maximum: 2.6

Discussion: The source density parameter is used to calculate the total amount of radionuclides in the source volume, and it affects the external pathway doses. In the RESRAD-BUILD code, the volume source can be defined with up to five distinct parallel regions (or layers) located along the direction parallel to the partition, each consisting of homogeneous and isotropic materials. RESRAD-BUILD allows the following eight materials: concrete, water, aluminum, iron, lead, copper, tungsten, and uranium. Each source layer is defined by its physical properties, such as thickness, density, porosity, radon effective diffusion coefficient, radon emanation fraction, and erosion rate.

Table C-95 lists the density range (if appropriate) or a single value of density for the RESRAD-BUILD materials that have a narrow range of density (except concrete). The table lists a range for cast iron and a single value of density for each of the other materials. The values are taken from the Health Physics and Radiological Health Handbook (Shleien, 1992) and from the CRC Handbook of Chemistry and Physics (Lide, 1998; for cast iron, uranium and tungsten). Table C-96 provides the concrete density from three different sources: Health Physics and Radiological Health Handbook (Shleien, 1992), Properties of Concrete (Neville, 1996), and Standard Handbook for Civil Engineers (Merritt et al., 1995). The value used in the code is for ordinary concrete. If the type of concrete is known, a uniform distribution between the given range for a known concrete type can be used. The probability density function for the concrete source density is shown in Figure C-66.

Table C-95 Density of Source Materials (except concrete) Allowed in RESRAD-BUILD

Material	Density Range (g/cm^3)	Normal Density (g/cm^3)
Aluminum	–[a]	2.7
Copper	–	8.96
Lead	–	11.35
Steel	–	7.8
Cast iron	7.0–7.4	–
Water	–	1.0
Tungsten	–	19.3
Uranium	–	19.1
Iron	–	7.87

[a] Dash means data not available.
Sources: Shleien (1992); Lide (1998).

Table C-96 Concrete Density from Various Sources

Aggregate	Concrete Density (g/cm^3)		
	Shleien (1992)	Neville (1996)	Merritt et al. (1995)
Ordinary (silicacious) or normal weight	2.2–2.4	2.2–2.6	2.3
Heavy weight	–[a]	–	2.4-6.15
Limonite (goethite, hyd. Fe_2O_3)	2.6–3.7	–	–
Ilmenite (nat. $FeTiO_3$)	2.9–3.9	–	–
Magnetite (nat. Fe_3O_4)	2.9–4.0	–	–
Limonite and magnetite	–	–	3.35–3.59
Iron (shot, punchings, etc.) or steel	4.0–6.0	–	4.0–4.61
Barite	3.0–3.8	–	3.72
Lightweight	–	0.3–1.85	0.55–1.85
Pumice	–	0.8–1.8	1.45–1.6
Scoria	–	1.0–1.85	1.45–1.75
Expanded clay and shale	–	1.4–1.8	–
Vermiculite	–	0.3–0.8	0.55–1.2
Perlite	–	0.4–1.0	0.8–1.3
Clinker	–	1.1–1.4	–
Cinders without sand	–	–	1.36
Cinders with sand	–	–	1.75–1.85
Shale or clay	–	–	1.45–1.75
Cellular	–	0.36–1.55	–
No-fines	–	1.6–2.0	1.68–1.8
No-fines with light weight aggregate	–	0.64–higher	–
Nailing	–	0.65–1.6	–
Foam	–	–	0.3–1.75

[a] Dash means data not available.

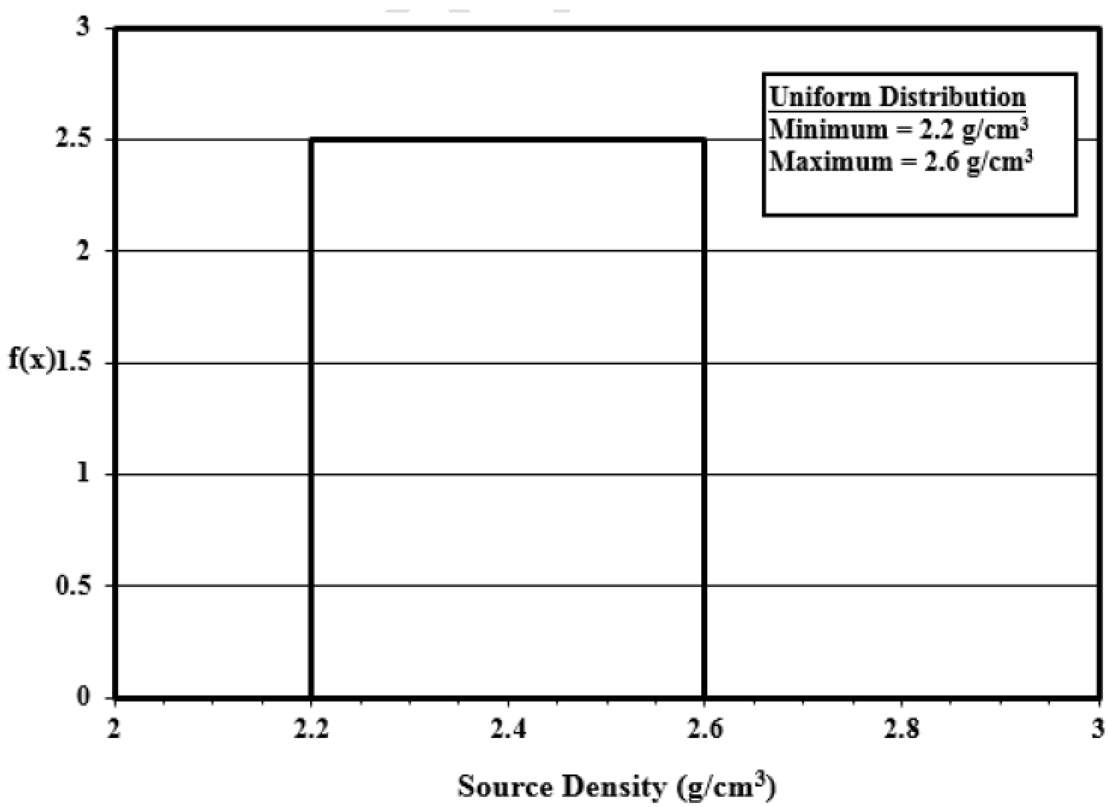

Figure C-66 Concrete Source Density Probability Density Function

C.8.2 Source Erosion Rate, Volume Source

Applicable Code: RESRAD-BUILD

Description: The source erosion rate parameter represents the amount of contaminated material [expressed as the thickness of the layer (distance perpendicular to the contaminated surface)] removed per unit of time.

Units: centimeters per day (cm/d)

Probabilistic Input:

Distribution: triangular

Defining values for distribution:

Minimum: 0.0 Maximum: 5.6E-07 Most likely: 0.0

Discussion: The source erosion rate is highly dependent on the location of the contamination. In the building occupancy scenario, contamination on walls could remain indefinitely if located in little-used areas not subject to periodic washing or cleaning. Furthermore, such residual wall contamination could have been covered with paint or another type of sealant during prior remediation or general maintenance activities. In addition, little or no wear also can be expected for some floor areas for the same reasons. At the other extreme are contaminated floor areas subject to heavy foot traffic or vehicle traffic, such as in warehousing operations. However, such areas are usually covered (carpet or tile), sealed, or waxed on a periodic basis, thus reducing the potential for erosion.

A triangular distribution was selected to represent the source erosion rate. A value of 0 was chosen for both the minimum and most likely values because contamination on both walls and floors in little-used areas can be expected to remain in place indefinitely. Even high-use areas may not experience erosion if they remain protected by paint or sealant. Under normal occupancy conditions (not remedial activities), a maximum value is expected as a result of traffic over floor areas. Contaminated wood, concrete, and (possibly) ceramic tile are expected to be the primary flooring materials affected. Contaminated carpet would be expected to have been removed by remedial activities. However, aside from studies on abrasion, little information is available in the general literature on normal wear of concrete or wood surfaces over extended periods of time.

A rough approximation for the maximum value can be obtained by considering that any eroded materials would become airborne for at least short periods of time. A conservative assumption was made that all airborne indoor particulate matter is a result of erosion of the floor surface. Typically, outdoor air is a significant source of indoor air particulate concentrations (see Section C.7.1), but this contribution was not considered. The erosion rate of a concrete floor was estimated to maintain an average particulate air concentration of 100 $\mu g/m^3$ with a room air exchange rate of 1.52/h (Section C.7.4). A floor area of 36 m^2 (Section C.7.7), a room height of 3.7 m (Section C.7.8, used to estimate the room volume), and a concrete density of 2.4 g/cm^3 (Section C.8.1) were used. The estimated erosion rate was 5.6E-07 cm/d. Figure C-67 shows the probability density function used for the source erosion rate.

In the case of renovation or remedial actions, the source erosion rate can be quite high. For example, thin-volume sources in wood or concrete could be removed in seconds with power sanders or sandblasting techniques. Other examples include the complete removal of wood, carpet, or drywall sections within seconds to minutes. For such a scenario, the user can input values appropriate to the contaminated source and removal technique under consideration.

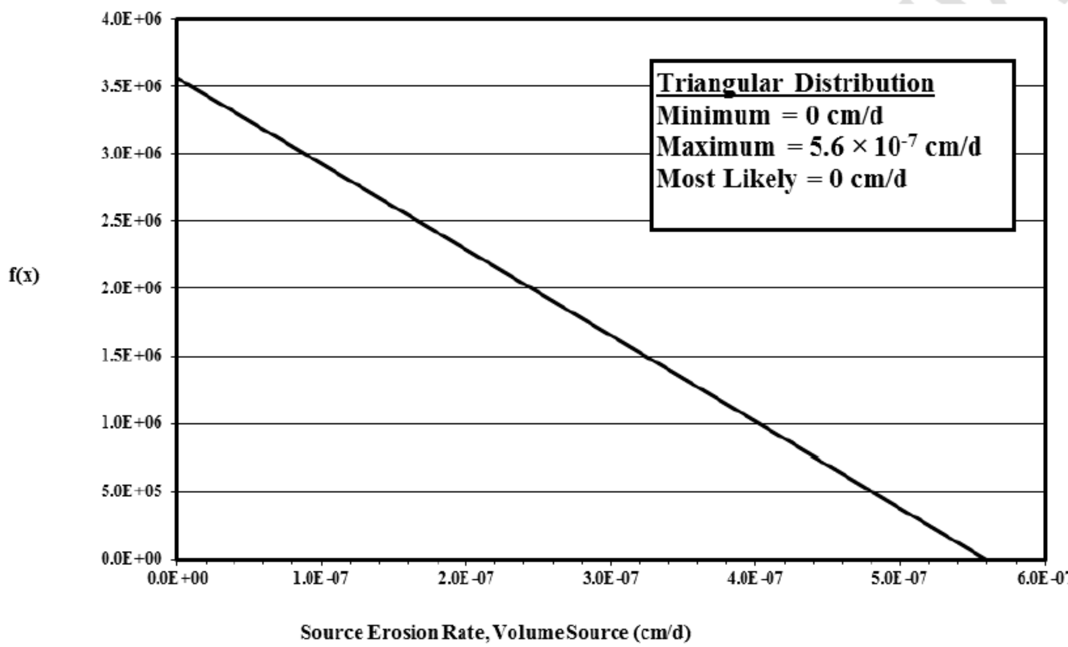

Figure C-67 Source Erosion Rate Probability Density Function

C.8.3 Removable Fraction

Applicable Code: RESRAD-BUILD

Description: The removable fraction is the fraction of a line or area source that can be removed.

Units: no units

Probabilistic Input:

Distribution: triangular

Defining values for distribution:

Minimum value: 0.0 Maximum value: 1.0 Most likely: 0.1

Discussion: The removable fraction can account for various events that reduce the amount of source activity over time. In RESRAD-BUILD calculations, this fraction of the source will be linearly removed between time 0 and the “time of source removal.” Source activity may be reduced over a period of time as a result of such events as surface washing (chemical and mechanical action) or foot or equipment traffic if the source is on the floor (mechanical action). Because source activity could remain on a wall indefinitely or be removed entirely because of heavy traffic across floor contamination, the default distribution for the removable fraction ranges from 0 to 1 for use in a triangular distribution.

For most radionuclides, the DOE Radiological Control Manual (DOE, 1994a) allows a maximum removable concentration that is 20 percent of the maximum allowable total surface contamination for most radionuclides except for some transuranics and tritium (Table 2-2 in

DOE, 1994a). The maximum allowed removable transuranic or tritium contamination is 4 percent or 100 percent, respectively, of the maximum allowable surface contamination. However, conditions may exist under these restrictions for unrestricted use where for all radionuclides, the removable surface contamination constitutes 20 percent of the surface contamination. For the NRC, maximum acceptable removable concentrations are 10 percent of the average surface concentrations for all radionuclides (NRC 2000). Like the DOE regulations, however, the removable fraction can be higher than 0.1 if overall surface concentrations are lower. Thus, a triangular distribution, as shown in Figure C-68, is suggested for the removable fraction, with a most likely value of 0.1 and minimum and maximum values of 0 and 1, respectively, as discussed above.

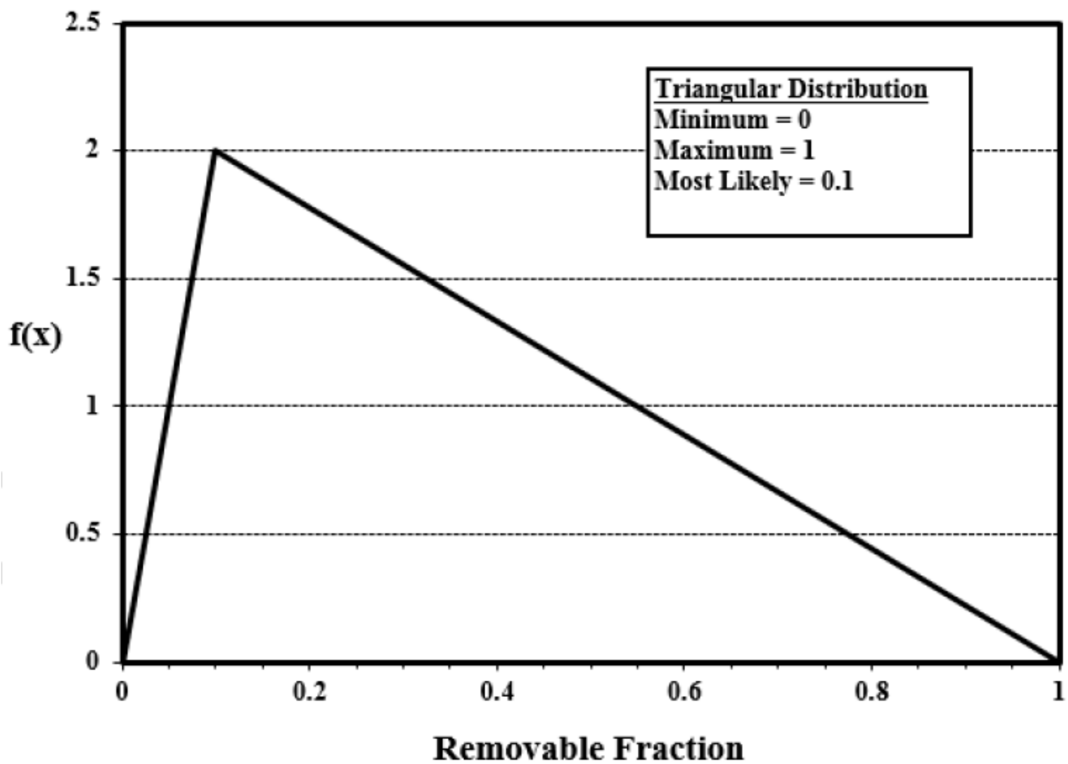

Figure C-68 Removable Fraction Probability Density Function

For specific situations, a number of factors must be considered, including location of the contamination (e.g., wall or floor and proximity to human activity), the nature of the contaminated surface (e.g., type of material [chemical and physical properties]), the original form of the contaminant (chemical and physical properties [e.g., powder versus liquid and chemical reactivity]) and the removal mechanism (such as washing or foot traffic).

Smear tests are often used to determine the amount of “fixed” versus “non-fixed” (or removable) contamination (Frame and Abelquist, 1999). Although the definition of removable contamination varies, it applies to radioactive “contamination which is removable or transferrable under normal working conditions” (International Organization for Standardization [ISO], 1988) or “radioactivity that can be transferred from a surface to a smear test paper by rubbing with moderate pressure” (NRC, 1979a,b) or “radioactive material that can be removed from surfaces by non-destructive means such as casual contact, wiping, brushing, or washing" (DOE, 1994a). However, smear tests can vary because of the material of the smear wipes used and the potential use of a wetting agent (Frame and Abelquist, 1999). Also, smear tests will vary according to the contaminant, the surface, and the pressure and technique used by each technician performing the test (Sansone 1987; Jung et al. 2001). Table C-97 lists results from early experiments demonstrating that the nature of the contamination and of the surface can influence how easily removable the radioactive contamination can be. Thus, a specific distribution for the removable fraction must be made on a case-by-case basis. Other measurement tests in the past have included tape and modified air sensor tests. Table C-98 presents some results comparing these methods with smear tests on different surfaces.

In assigning a removable fraction, a numer of factors must be taken into account. In a decommissioned and decontaminated building, any residual contamination might be expected to be predominantly fixed because decontamination efforts should have used reasonable steps in cleaning the building. Weber (1966) demonstrated that up to 99.9 percent of deposited (dried solution) radioactive surface contamination could be removed in some cases by using the proper cleaning solution. This removal efficiency is much higher than that shown by smears or other sampling methods (e.g., see Table C-98). Thus, the removable fraction is highly dependent on the decommissioning activities used to bring the building surfaces into compliance and future on housekeeping activities.

No information appears to be available regarding smear tests on freshly cleaned surfaces. Smears may be more indicative of what contamination is available for removal by such processes as resuspension. Multiple smears on the same area may also be used in determining the removal fraction (Frame and Abelquist 1999). Jung et al. (2001) studied the effect of multiple smears on stainless steel (with different surface finishes), aluminum, and titanium metal samples after submersion in a spent fuel storage pool. In each case, the tenth consecutive smear contained approximately 5–10 percent of the total removed contamination for all 10 smears. Extrapolating their smear results for the stainless-steel samples, Jung et al. (2001) estimated the total removable contamination to be approximately 8–11 percent; the first smear picked up only 2–4 percent of the removable contamination.

Table C-97 Influence of Surface and Contaminant Types on Smear Tests

Percentage Contamination Removed	Contamination	Surface	Comments	Reference
1–3	Low level from normal use	Granolithic concrete floor		Brunskill (1967)
50			Water wash of floor	
0.1–0.2	Plutonium nitrate	Paper	Plutonium nitrate or oxide in solution was applied to the floor and allowed to dry for 16 hours	Jones and Pond (1967)
6		Waxed and polished linoleum		
20–30		Polyvinyl chloride		
10–20	PuO_2	Polyvinyl chloride		
20–30		Unwaxed linoleum		
50–60		Waxed and polished linoleum		

Table C-98 Percent Removal of Contamination for Different Sampling Methods

Surface	Removal (percent)		
	Adhesive Paper	Smear	Modified Air[a]
Polyethylene	70.3	56.6	10.9
Glass	75.0	64.6	27.2
Plexiglass	78.0	71.3	15.8
Fiberboard (waxed)	53.8	44.3	10.2
Fiberboard (scrubbed)	56.9	23.5	9.0
Fiberboard (untreated)	73.4	23.5	6.6
Formica	73.4	70.6	26.5
Aluminum (painted)	70.0	50.3	24.8
Asphalt floor tile (untreated)	58.6	48.5	14.6
Asphalt floor tile (waxed)	74.5	74.5	30.3
Concrete (unsealed)	55.5	39.5	22.0
Concrete [sealed (seal and wax 1)]	62.2	59.5	24.0
Concrete [sealed (seal and wax 2)]	54.8	47.7	27.2
Concrete (greased)	43.5	37.5	1.32
Stainless steel	67.7	50.5	10.5

[a] Modified air sampler (referred to as a "smair" sampler by the authors) causes air intake to blow across the sample surface when the sample head is pressed against a surface.

Source: Royster and Fish (1967); contamination was simulated by thorium dioxide dust particles approximately 1 μm in diameter at a concentration of about 1.0E+06 particles per square centimeter.

C.8.4 Concrete Source Porosity

Applicable Code: RESRAD-ONSITE, RESRAD-OFFSITE, RESRAD-BUILD

Description: The source porosity is the ratio of the pore volume to the total volume of a representative sample of the source material.

Units: no units

Probabilistic Input (allowed only for concrete):

Distribution: triangular

Defining values for distribution:

Minimum: 0.04 Maximum: 0.25

Discussion: The source porosity parameter is used in RESRAD-BUILD to calculate the diffusion of radon and tritium from a volume source and is applicable to the tritium inhalation and the radon inhalation pathways. This parameter is only required as input if a tritium volume source is selected or if radon (radon-220 and radon-222) precursors are entered as part of the volume source.

The building foundation total porosity parameter is used in RESRAD-ONSITE and RESRAD-OFFSITE to calculate the diffusion of radon from the building foundation and is applicable to the radon inhalation pathways. This parameter is only required as input if radon (radon-220 and radon-222) precursors are entered as part of the volume source.

Porosity may range from 0–1 and may be reported as a decimal fraction or as a percentage. Input to the codes is as a decimal fraction. A value of 0 represents a material that is completely solid, without any void spaces. On the other extreme, a porosity approaching 1 represents a material that is made up mostly of void spaces. Building materials such as concrete, brick, or rock typically have porosities ranging from 0–0.3.

Widespread variations in concrete porosity are observed because of the differences in the aggregates used, water/cement ratios in the cement paste, and curing conditions. Cement paste in concrete occupies from 23–36 percent of the total volume (Culot et al., 1976); sand occupies 25–30 percent, and the remainder is aggregated. Overall porosity of concrete depends on the porosity of the cement paste as well as of the aggregates. The porosity of concrete was found to range from 0.05–0.25 (Culot et al., 1976).

The porosity estimated for a concrete structure made of Portland cement was found to vary from 0.04–0.20 (Frankowski et al., 1997). Table C-99 gives the bulk density and porosity of the rocks commonly used as building materials (Bever, 1986). Materials used for thermal insulation tend to have a very high air content, with porosities approaching 1. Material porosity tends to be inversely correlated with material density; low porosity materials tend to have higher densities than any porous materials.

On the basis of the definition of porosity, the porosity of a material could be evaluated by directly measuring the pore volume and the total volume. The American Society for Testing and Materials (ASTM) has established a standard procedure (B 276) for cemented carbide to rate three types of porosities, depending on the pore diameters (Type A, pore diameters < 10 μm;

Type B, pore diameters between 10 and 25 μm; and Type C, covering porosity developed by the presence of free carbon). Similarly, ASTM has developed standard test methods for porosity of metal structure parts, and porosity tests for electrodeposits and related metallic coatings (http://www.astm.org/sitemap.html).

For generic applications, a uniform distribution from 0.04–0.25 is suggested for the source porosity for concrete. The minimum and maximum values were those reported by Frankowski et al. (1997) and Culot et al. (1976), respectively. The probability density function is shown in Figure C-69.

Table C-99 Bulk Density and Porosity of Rocks Commonly Used as Building Materials

Rock	Bulk Density (g/cm^3)	Porosity (percent)
Granite	2.6–2.7	0.5–1.5
Basalt	2.8–2.9	0.1–1.0
Sandstone	2.0–2.6	0.5–25.0
Limestone	2.2–2.6	0.5–20.0
Gneiss	2.9–3.0	0.5–1.5
Marble	2.6–2.7	0.5–2.0

Source: (Bever 1986).

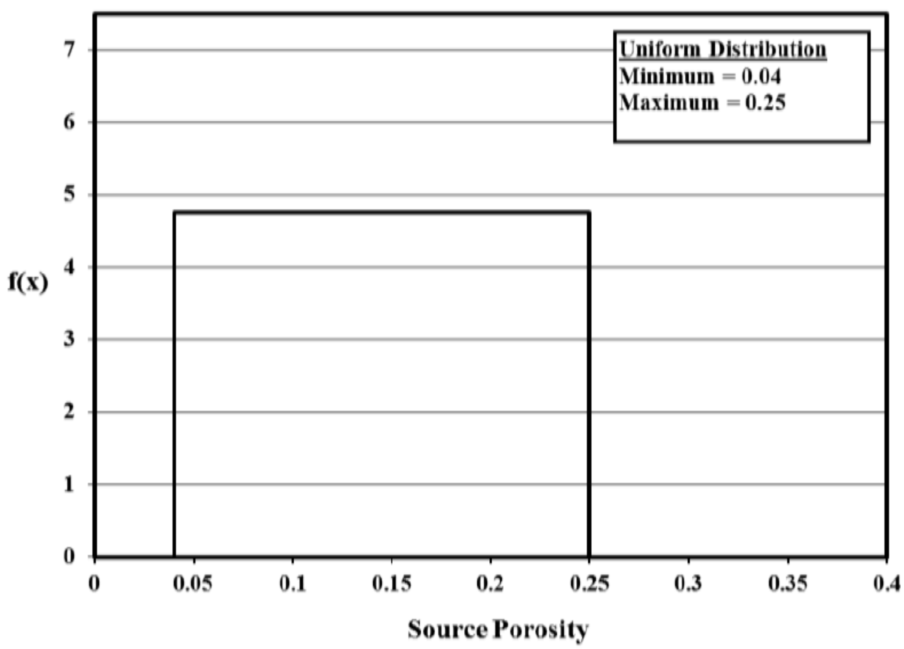

Figure C-69 Concrete Source Porosity Probability Density Function

C.8.5 Air Release Fraction

Applicable Code: RESRAD-BUILD

Description: The air release fraction is the amount of the contaminated material removed from the source that is released into the air and in the respirable particulate range.

Units: no units

Probabilistic Input:

Distribution: triangular

Defining values for distribution:

Minimum: 1.0E-06 Maximum: 1 Most likely: 0.07

Discussion: The fraction released to the air is the amount of the contaminated material removed from the source that is actually suspended in air; the balance of the material is assumed to be instantaneously removed from the room. It is a dimensionless parameter that can range from 0 (all eroded material is removed instantaneously from the room) to 1 (all eroded material is suspended instantaneously in the respirable room air). This parameter depends strongly on the erosion process. Dusting would result in low erosion rates, but a relatively high fraction of removed material may become suspended in air. Vacuuming may result in higher erosion rates than dusting, but a smaller fraction would become airborne; a significant fraction would be trapped in the vacuum. Mechanical disturbances such as sanding, scraping, or chipping result in a high contaminant removal rate but usually generate a relatively small fraction of particulates released to air. Most of the eroded material tends to fall to the floor and is removed from the room by housekeeping activities.

The RESRAD-BUILD code requires an air release fraction input for each source. Entering 0 means that none of the removable material will be released to the air that is respirable. The dose contributions from deposition, immersion, dust inhalation, and indirect ingestion are effectively suppressed. Entering 1 is very conservative because it will maximize the dose contributions from these pathways. Note that if either the removable fraction or erosion rates are 0, the contributions from these pathways will be suppressed no matter what value is given to the air release fraction.

The DOE handbook on airborne release and respirable fractions (RFs) (U.S. Department of Energy 1994) provides a compendium and analysis of experimental data from which airborne release fractions6 (ARFs) and RFs7 may be derived. The data are given by the physical form of the material affected (e.g., gas, liquid, solid, surface contamination) and different suspension stresses (e.g., spill, thermal stress, shock wave, blast stress). The ANS has published an American National Standard for airborne release fractions at nonreactor nuclear facilities (American Nuclear Society 1998).

For materials in gaseous form, such as H-3, the recommended airborne release fraction is 1.0. All materials in the gaseous state can be transported and inhaled; therefore, the respirable fraction is also 1.0 (U.S. Department of Energy 1994).

The Department of Energy (DOE) handbook provides release fractions for three categories of solid materials: metals, nonmetallic or composite solids, and powders. The bounding ARF for plutonium metal formed by oxidation at elevated temperature was found to be 3.0E-05, with an RF value of 0.04. ARF and RF values of 1.0E-03 and 1.0 were assessed to be bounding during complete oxidation of metal mass (U.S. Department of Energy 1994). The bounding values for contaminated, noncombustible solids were found to be 0.1 and 0.7 for ARF and RF, respectively (these release values are for loose surface contamination on the solid, not the solid as a whole).

Little information is available for the building occupancy scenario air release fraction; therefore, a triangular distribution based on above data is used to generate distribution. The maximum value is assumed to be 1 (for gaseous forms), the minimum value chosen is that for plutonium metal (3.0E-05 × 0.04 = 1.2E-06), and the mode (most likely value) is the bounding value for contaminated noncombustible solids (0.1 × 0.7 = 0.07). The probability density function is displayed in Figure C-70.

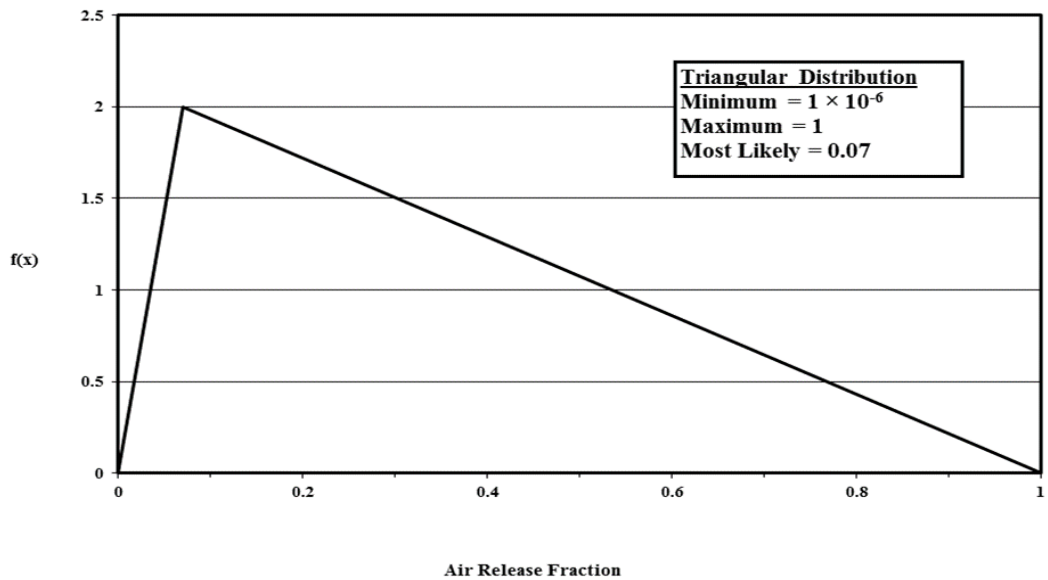

Figure C-70 Air Release Fraction Probability Density Function

C.8.6 Wet & Dry Zone Thickness

Applicable Code: RESRAD-BUILD

Description: This parameter represents the depth from the surface of the contaminated material to the deepest point of the contaminated zone.

Units: centimeters (cm)

Probabilistic Input (allowed only for volume contamination with tritium):

Distribution: uniform

Defining values for distribution:

Minimum: 5Maximum: 30

Discussion: The wet + dry zone thickness parameter is used in RESRAD-BUILD in modeling the emission rate of tritiated water (HTO) vapor from the contamination source to the indoor atmosphere. In a tritium-handling facility, tritium contamination of the construction material and the equipment is recognized as an important source in defining the requirements for atmospheric cleanup and personnel protection. Tritium released during the handling process can quickly sorb to surfaces of the surrounding materials (e.g., concrete walls and floors) and can diffuse through many of them, resulting in contamination of the bulk as well as of the surface. The tritium that is absorbed/adsorbed to the surrounding materials can then be desorbed and released to the indoor air. This sorption/desorption process is generally referred to as the “tritium soaking effect” in tritium-handling facilities.

Tritium released from the tritium-handling facilities can be in different chemical forms; the most common ones are tritium gas (HT) and tritium oxide, or HTO. In general, sorption and desorption of HT occurs faster than that of HTO; however, the total amount sorbed and desorbed is greater for HTO than for HT (Wong et al. 1991; Dickson and Miller 1992). On the other hand, HT can easily be converted to HTO in the environment. Experimental data concerning the tritium soaking effect on construction metals also showed that about 90 percent of the tritium desorbed from metal samples was in the form of HTO, although the samples were exposed to an atmosphere of HT (Dickson and Miller 1992). Because of the conversion from HT to HTO and the potentially longer time required for degassing of HTO (desorption and subsequent release from the contaminated material to the indoor air), the tritium model incorporated into the RESRAD-BUILD code considers only the potential degassing of HTO after the tritium handling operation ended.

Among all the materials that can become contaminated, concrete is of special concern because of its porous nature. The high porosity of concrete materials makes them more vulnerable to the permeation of tritiated water, which can spread out inside the concrete matrix after the initial surface absorption/adsorption. In RESRAD-BUILD, the degassing (i.e., the release) of the HTO vapor is assumed to be controlled by diffusion of the free HTO molecules from inside of the concrete matrix to the concrete-atmosphere interface (the “free” molecules are the HTO molecules that are not bound to the concrete matrix and are available for diffusion, see discussion for the “water fraction available for evaporation” parameter, Section C.8.9).

The diffusion of HTO is assumed to proceed like a peeling process in which the HTO molecules closer to the concrete-atmosphere interface will be released earlier than those farther from the interface. As the release process continues, a region free of free HTO molecules (i.e., the dry zone), will be formed, and its thickness will increase over time. The dry zone thickness then represents the path length for the subsequent diffusion. The region inside the concrete where the free HTO molecules are distributed is called the wet zone. As the dry zone becomes thicker, the thickness of the wet zone decreases accordingly. In fact, the sum of the dry zone thickness and the wet zone thickness is assumed to remain the same throughout the diffusion process.

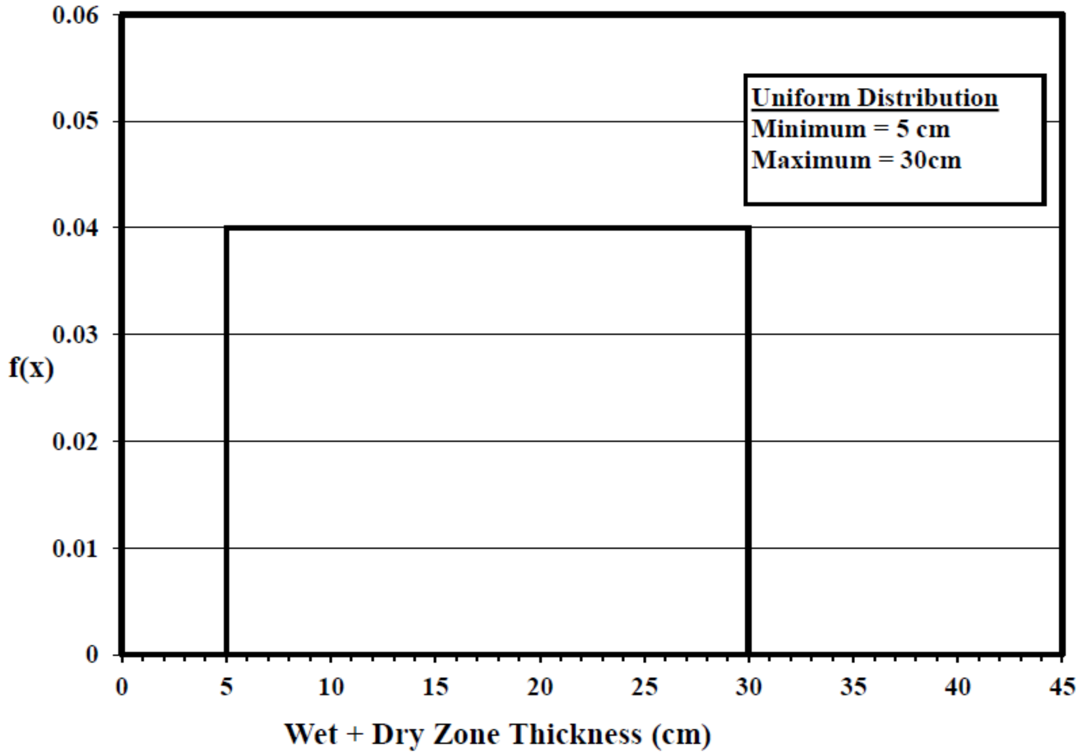

Figure C-71 Wet +Dry Zone Thickness Probability Density Function

Although diffusion of the HTO vapor to the bulk of concrete materials in a tritium handling facility is recognized (Wong, et al. 1991), direct detection of the extent of spreading into the bulk (i.e., dry+ wet zone thickness) is not possible because of the short range of the beta radiation (DOE, 1991). However, judging by the high porosity of concrete materials, spreading of the HTO vapor throughout the entire thickness is possible if the exposure is of sufficient duration. Therefore, the thickness of the concrete wall is assumed for the "dry + wet zone thickness" parameter, which, on the basis of engineering judgments, can be as much as 30 cm. A low bound of 5 cm is selected because bulk contamination will not be extensive for a short exposure period. The probability density function is shown in Figure C-71.

C.8.7 Time for Source Removal or Source Lifetime

Applicable Code: RESRAD-BUILD

Description: This parameter represents the time over which the removable part of the source is (linearly) eroded. The parameter is used in conjunction with the "removable fraction of source material" parameter (Section C.8.3) and the "air release fraction" (Section C.8.5) to obtain the emission rate of radionuclides into the indoor air.

Units: days (d)

Probabilistic Input (allowed only for surface contamination):

Distribution: triangular

Defining values for distribution:

Minimum: 1,000 Maximum: 100,000 Most likely: 10,000 (27.4 yr.)

Discussion: The RESRAD-BUILD model considers the potential entrainment of loose contamination from a contaminated surface to the indoor atmosphere. The entrainment rate of the loose contamination is calculated by using the “removable fraction” parameter, the “time for source removal or source lifetime” parameter, and the total contaminant inventory on the surface. Information on the “time for source removal or source lifetime” parameter is not directly available from the open literature; therefore, the potential range of this parameter was inferred on the basis of information on other, related parameters.

Different mechanisms can result in the entrainment of loose surface particles to the atmosphere. Mechanical abrasion during renovation activities would result in the highest entrainment rate in the shortest period of time. However, for normal building occupancy conditions, renovation activities were excluded from consideration.

According to the American Nuclear Society, an air release rate of 4.0E-05 h^{-1} is a conservative value for use in estimating the potential exposure resulting from release of solid powders piled up on a heterogeneous surface (e.g., concrete, stainless steel, or glass) under the condition of normal building ventilation flow (American Nuclear Society 1998). That rate is equivalent to a lifetime of approximately 1,040 days (or 2.85 years). Although the loose particles on the contaminated source are not exactly the same as a pile of solid powders, the value for the free solid powders can be used to derive a lower bounding lifetime value for the loose materials.

Another suggestion by the ANS is an air release rate of 4.0E-06 h^{-1} for solid powders that are covered with a substantial layer of debris or are constrained by indoor static conditions (American Nuclear Society 1998). This rate is equivalent to a lifetime of approximately 10,000 days (27.4 yr.). The loose contaminants on a contaminated surface can be considered as being restricted by some weak physical binding force and would, therefore, behave like the constrained solid powders. The lifetime of the constrained solid powders can be used as the most likely value for the loose contaminants.

Erosion of the surface layer from the contaminated material can eventually occur over a long period of time, if there is no constant maintenance. Therefore, all the loose contaminants have the opportunity of being released to the environment. To consider this extreme case, a lifetime of 300 years (~100,000 days) was assumed. The probability density function is shown in Figure C-72.

Another factor that is frequently used in the literature for estimating air concentrations from surface sources is the resuspension factor. The resuspension factor is not used in the RESRAD-BUILD code, but it is a quantity closely related to the source lifetime for a surface source.

The air release fraction in RESRAD-BUILD is the fraction of contaminated material removed from the source released into the air that is in the respirable particulate range. Assuming a surface source on the floor with a removable fraction of 0.1 and an air release fraction of 0.07, the resuspension factor can be estimated from the source lifetime. A floor area of 36 m^2, a room height of 3.7 m, and a room air exchange rate of 1.52 h^{-1} were used. In this case, the source lifetime of 10,000 days is equivalent to a resuspension factor of 5E-09 m^{-1} (Yu et al. 2003).

Table C-100 gives the source lifetime (days) for different air exchange rates and heights for a fixed resuspension factor of 1.0E-06 m^{-1}. For these calculations, the removable fraction is 1, and the fraction that becomes airborne is also 1. With an airborne fraction of 1, an air exchange rate of 0.5 h^{-1}, and a room height of 2.3 m are assumed, the source lifetime (in years) can be related to resuspension factor, as shown in Table C-101.

The source lifetime depends on how easily the source material can be removed and the external conditions to which the source is exposed (e.g., corrosion, mechanical contact, heat). If the source is fixed, the removable fraction should be set to 0, so the source lifetime is immaterial. The code assumes a linear removal over time. For example, for a source with a lifetime of 1 year, 50 percent of the removable fraction is assumed to be removed after 6 months. The code requires a source lifetime for each area, line, and point source whenever a nonzero removable fraction is entered. If the removable fraction for a source is 0, the code ignores any lifetime value entered by the user for that source.

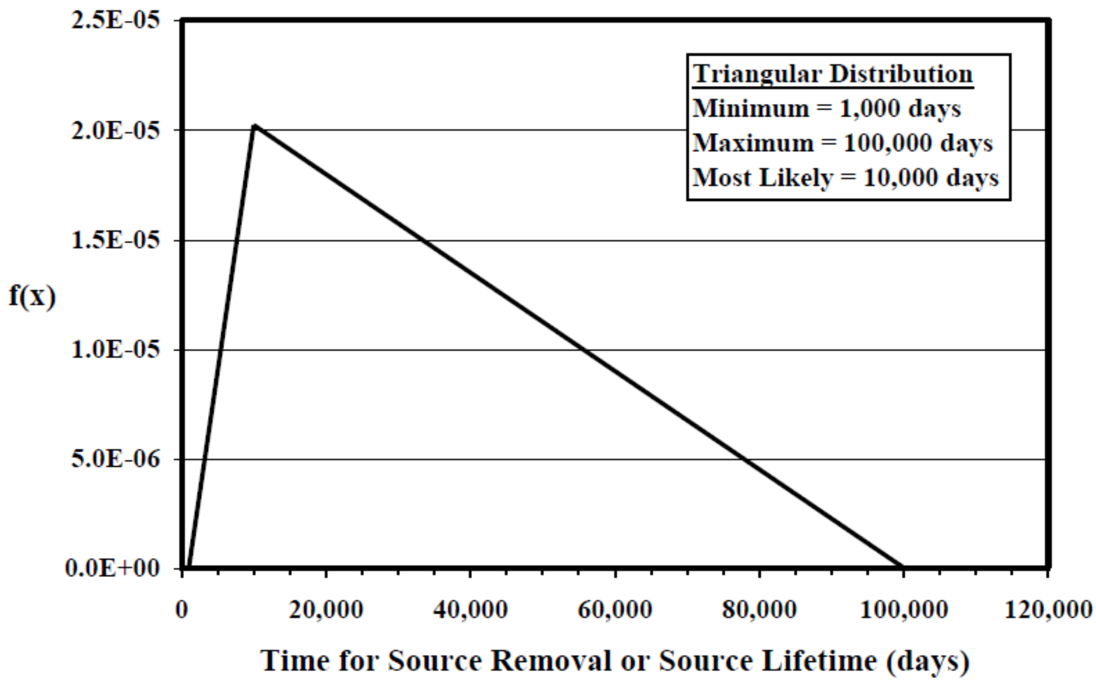

Figure C-72 Time for Source Removal or Source Lifetime Probability Density Function

Table C-100 Source Lifetime (d) Variation with Air Exchange Rate and Room Height for a Fixed Resuspension Factor of 1E-6 m^{-1}

Height (m)	Air Exchange Rate (h^{-1})				
	0.2	0.5	0.8	1.0	1.5
2.5	8.3E+04	3.3E+04	2.1E+04	1.7E+04	1.1E+04
3.0	6.9E+04	2.8E+04	1.7E+04	1.4E+04	9.3E+03
6.0	3.5E+04	1.4E+04	8.7E+03	6.9E+03	4.6E+03
10.0	2.1E+04	8.3E+03	5.2E+03	4.2E+03	2.8E+03

Table C-101 Source Lifetime (yr.) and Resuspension Factor for Different Removable Fractions for a House with an Air Exchange Rate of 0.5 h^{-1} and a 2.3-m Room Height

Resuspension Factor (m^{-1})	Removable Fraction (percent)	Source Lifetime (yr)
1E-08	100	10,000
	10	1,000
1E-06	100	100
	10	10
1E-04	100	1
	10	0.1

C.8.8 Source Thickness, Volume Source

Applicable Code: RESRAD-BUILD

Description: This parameter represents the thickness of each layer in an idealized volume source. This parameter does not apply to area, line, or point sources.

Units: centimeters (cm)

Probabilistic Input:

Distribution: triangular

Defining values for distribution:

Minimum: 2.5 Maximum: 30 Most likely: 15

Discussion: RESRAD-BUILD allows consideration of a total of five distinct regions (layers) in a volume source. The contamination is within these regions, and the total thickness of the volume source is the sum of the thicknesses of these regions. The code requires a source thickness (in centimeters) for every layer of each volume source. The source thickness depends upon the detail of modeling desired. For example, a wall could be modeled as a single layer or multiple layers (e.g., a sequence of paint, drywall, framing gap, drywall, and paint), with up to five layers per source. It is highly recommended that the source thickness be obtained from direct measurement or be estimated on the basis of the applicable building codes. The contaminated layer thickness and position should be based on site-specific measurement.

With the exception of sources resulting from neutron activation, most volume activity in buildings will be limited to small areas (hot spots) or rather shallow sources. For the case of neutron activation, volume sources could extend deep into the volume of a building structure. The thickness of building structure materials will place a limit on the potential thickness for volume sources. Ayres et al. (1999) noted that the contamination of concrete usually results from spills, contaminated dust, or other surficial deposition. In some instances, the contaminants may migrate into the concrete matrix, particularly over time and under environmental stresses. Cracks and crevices may also provide routes for contaminants to spread deeper into the concrete matrix. To estimate the total contaminated volume of concrete from DOE facilities, (Ayres and al. 1999) assumed contamination to 1-in. (2.5-cm) depth and an average concrete thickness of 12 in. (30 cm) in a building. For external exposure calculations, this thickness will approximate an infinite thickness for alpha-emitters, beta-emitters, and X-ray or low-energy photon emitters. D and D and RESRAD-BUILD use 15 cm as the default source thickness for a volume source.

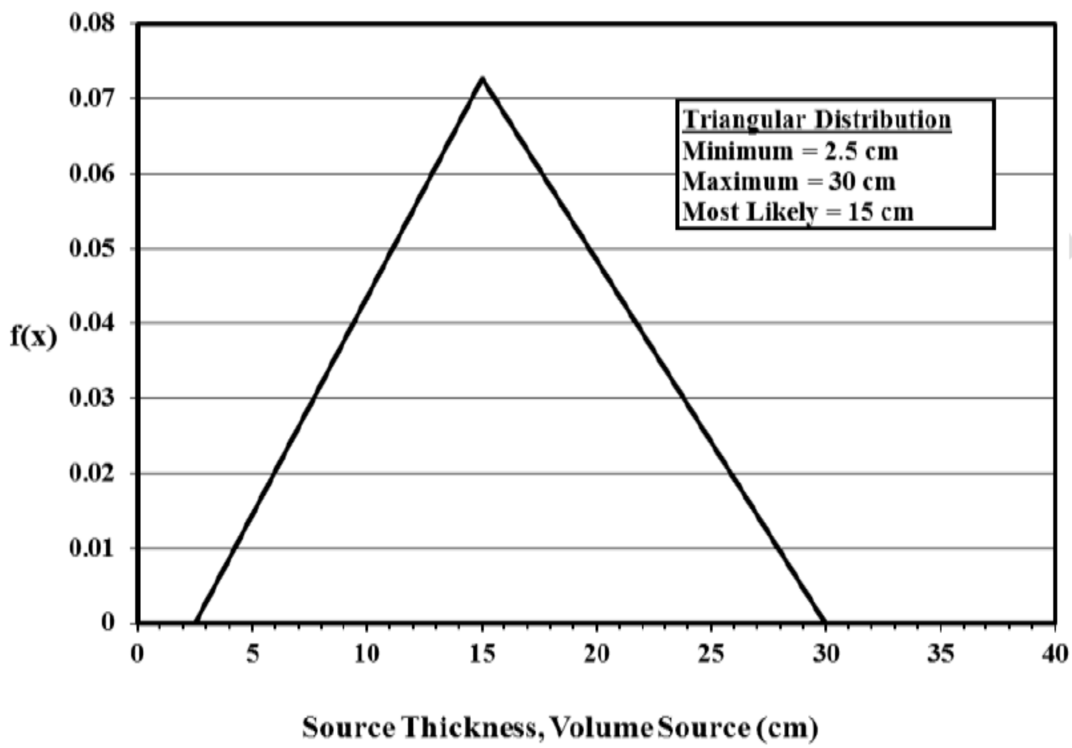

Figure C-73 Source Thickness Probability Density Function

Little information is available for the source thicknesses in real decommissioning and decontamination situations; therefore, on the basis of above data, a triangular distribution is assumed for source thickness. The maximum value is assumed to be 30 cm, the minimum value is chosen as 2.5 cm, and the most likely value is the 15-cm default used in D and D and RESRAD-BUILD codes for volume sources. Figure C-73 presents the probability density function for the source thickness.

C.8.9 Water Fraction Available for Evaporation

Applicable Code: RESRAD-BUILD

Description: This parameter is used in estimating the potential release rate of tritiated water (HTO) vapor from a volume contamination source. It is the fraction of the total amount of tritiated water that will be released to the indoor air through the diffusion mechanism under room temperature.

Units: no units

Probabilistic Input:

Distribution: triangular

Defining values for distribution:

Minimum: 0.5 Maximum: 1.0 Most likely: 0.75

Discussion: In a tritium-handling facility, tritium contamination of the construction material and the equipment is recognized as an important radiation source in defining the requirements for atmospheric cleanup and personnel protection. Tritium released during the handling process can quickly sorb to surfaces of the surrounding materials and can diffuse through many of them, resulting in both bulk (volumetric) and surface contamination. The tritium that is absorbed or adsorbed to the surrounding materials can then be desorb from the materials and released to the indoor air. This sorption/desorption process is generally referred to as the “tritium soaking effect” in tritium-handling facilities.

Tritium released from the tritium-handling facilities can be in different chemical forms; the most common ones are tritium gas (HT) and tritium oxide, or tritiated water (HTO). In general, sorption and desorption of HT occurs faster than that of HTO; however, the total amount sorbed and desorbed is greater for HTO than for HT (Wong, et al. 1991; Dickson and Miller 1992). On the other hand, HT can easily be converted to HTO in the environment. Experimental data concerning the tritium soaking effect on construction metals also showed that about 90 percent of the tritium desorbed from the metal samples was in the form of HTO, although the samples were exposed to atmosphere of HT (Dickson and Miller 1992). Because of the conversion from HT to HTO and the potentially longer time required for degassing of HTO (desorption and subsequent release from the contaminated material to the indoor air), the tritium model incorporated in the RESRAD-BUILD code considers only the potential degassing of HTO after the tritium-handling operation has stopped.

Among all the materials that can become contaminated, concrete is of special concern because of its porous nature. The high porosity of concrete materials makes them more vulnerable to the permeation of tritiated water, which can spread out inside the concrete matrix after the initial surface absorption/adsorption. In RESRAD-BUILD, the degassing (i.e. the release) of the HTO vapor is assumed to be controlled by diffusion of the HTO molecules from inside of the concrete matrix to the concrete-atmosphere interface.

The diffusion rate is estimated on the basis of information on extent of the contamination (thickness of dry zone, thickness of dry zone + wet zone, and area of contamination), characteristics of the source material (porosity and moisture content), tritium inventory (tritium concentration), and indoor humidity. Because not all the tritium in the source material is available for diffusion under ordinary building occupancy conditions, estimation of the release rate has to take into account the fraction of tritiated water available for evaporation and diffusion.

According to the experimental observations by (Numata and Amano 1988), water exists in concrete in two states: free water and bound water. Free water is the liquid water that fills the pore space and capillaries in the concrete. Bound water is the water that combines with constitute compounds in concrete or the constituent itself. The fraction of free water was determined by (Numata and Amano 1988) in their thermal desorption experiments as the fraction that was desorbed from concrete samples when the heating temperature was less than 200°C. The existence of free water versus bound water was verified in the investigation by (Ono, Tanaka and Yamawaki 1992), who studied sorption and desorption of tritiated water on paints. That study found that recovery of tritium sorbed to various paint materials was not complete by gas sweeping under 30°C. Residual tritium sorbed was recovered by heating up the samples up to 800°C. Although the samples used by Ono et al. (1992) were different from the concrete samples used by Numata and Amano (1988), it is quite conclusive that some tritiated water can form strong bounding with the source materials. In the RESRAD-BUILD tritium model, it is assumed that under ordinary building occupancy conditions, only the water that fills the pore space and capillaries of the concrete materials will evaporate and diffuse to the indoor atmosphere.

Numata and Amano (1988) reported that the fraction of free tritiated water in concrete samples depended on duration of the previous exposure of the samples to tritiated water vapor. Shorter exposure duration resulted in larger fraction of free tritiated water. However, as the exposure duration was increased to more than 60 days, equilibrium values were observed. The fraction of free tritiated water at equilibrium was 0.72 for hardened cement paste and 0.74 for mortar. The fraction of free ordinary water was lower than that for tritiated water because the ordinary water originally exists in the samples and was the residual water left during crystallization of the cement samples. The free fraction was about 0.58 for both hardened cement paste and mortar samples.

The free fractions of ordinary water reported by Numata and Amano (1988) are consistent with the suggestion in U.S. Department of Energy (1994) regarding the air release fraction of tritiated water from concrete materials under accidental conditions that can cause the temperature to reach as high as 200°C. Tritiated water was assumed in the DOE report to be used in concrete formation, which is the same role as ordinary water in Numata and Amano's experiments.

It can be deduced from the above discussions that (1) the free fraction of tritiated water in concrete materials used in tritium-handling facilities is greater than the free fraction of ordinary water in the same materials, and (2) the free fraction of tritiated water in the concrete materials can be very high if exposure duration of the concrete materials to tritiated water was very short. Therefore, a triangular distribution with a minimum of 0.5, a maximum of 1.0, and a most likely value of 0.75 was assumed for the "free water fraction available for evaporation" parameter. The probability density function is shown in Figure C-74.

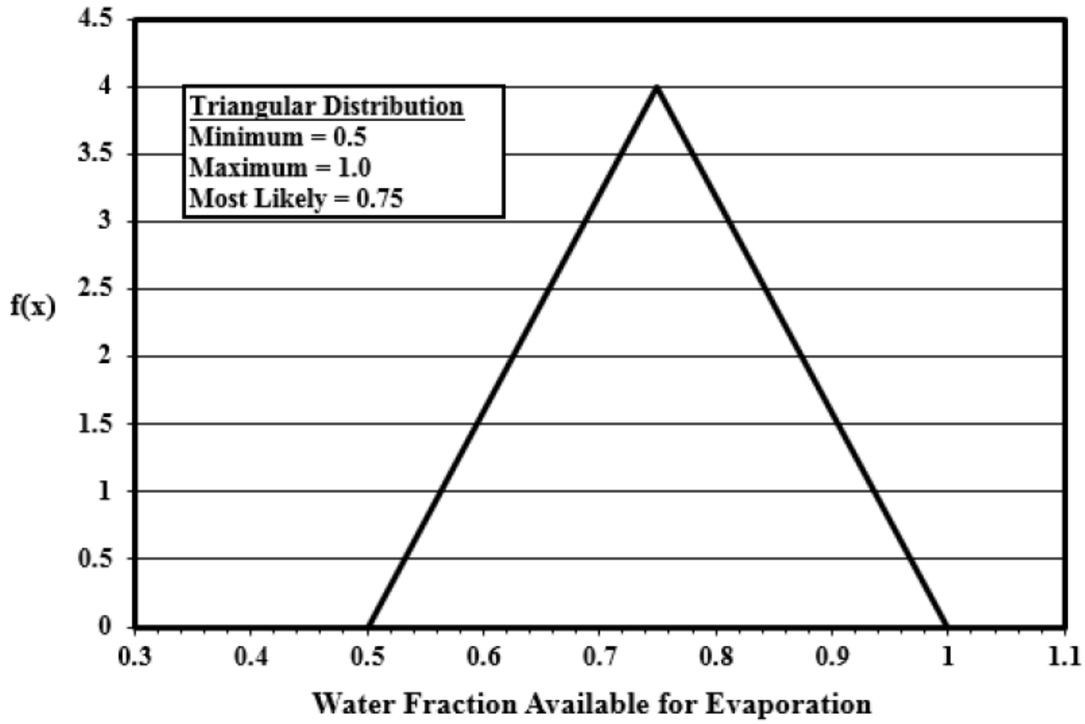

Figure C-74   Water Fraction Available for Evaporation Probability Density Function

C.8.10 Radon Emanation Coefficient

Applicable Code: RESRAD-BUILD, RESRAD-ONSITE and RESRAD-OFFSITE

Description: This parameter represents the fraction of the total amount of radon produced by radium decay that escapes the matrix of the contaminated material and gets into the pores of the medium.

Units: no units

Probabilistic Input:

Distribution: loguniform

Defining values for distribution:

Minimum: 0.005 Maximum: 0.83

Discussion: This parameter is also called the emanating power, emanation fraction, release ratio, and escape-to-production ratio. The radon emanation fraction is used by ONSITE, OFFSITE and BUILD codes in conjunction with the concentration of radium-226 and thorium-228 to calculate the release of radon-222 and radon-220, respectively, into the pore space of the source material and is only applicable to the radon inhalation pathway. It is only required as input when radionuclides that decay to radon are entered as part of the source material. It is not required for area, line, or point sources in BUILD code. Additional information on the radon emanation fraction can be found in the Data Collection Handbook (Yu, et al. 2015).

The radon emanation coefficient is a no unit parameter ranging in value from 0–1. Values approaching 0 indicate that the majority of the radon is retained in the matrix of the material and is not being released to the pore space. An emanation fraction approaching 1 indicates that most of the generated radon is being released to the pore spaces inside the contaminated material. The values of the radon-220 emanation coefficient for various source materials are listed in Table 4.2.1 of the data collection handbook (Yu, et al. 2015). The mean value varied from 0.01–0.14. The values of the radon-222 emanation coefficient for various source materials are listed in the data collection handbook Table 4.2.2 ((Yu, et al. 2015). The mean value varied from 0.03–0.20. The range was from 0.005–0.83. Based on this information loguniform distribution with minimum value of 0.005 and maximum value of 0.83 was assigned to radon emanation coefficient. The probability density function for the radon emanation coefficient is shown in Figure C-75.

In BUILD code, radon emanation coefficient must be entered for a contaminated layer of each volume source considered. Setting a value of 0 for the radon emanation coefficient in a contaminated layer of a volume source effectively suppresses the radon pathway.

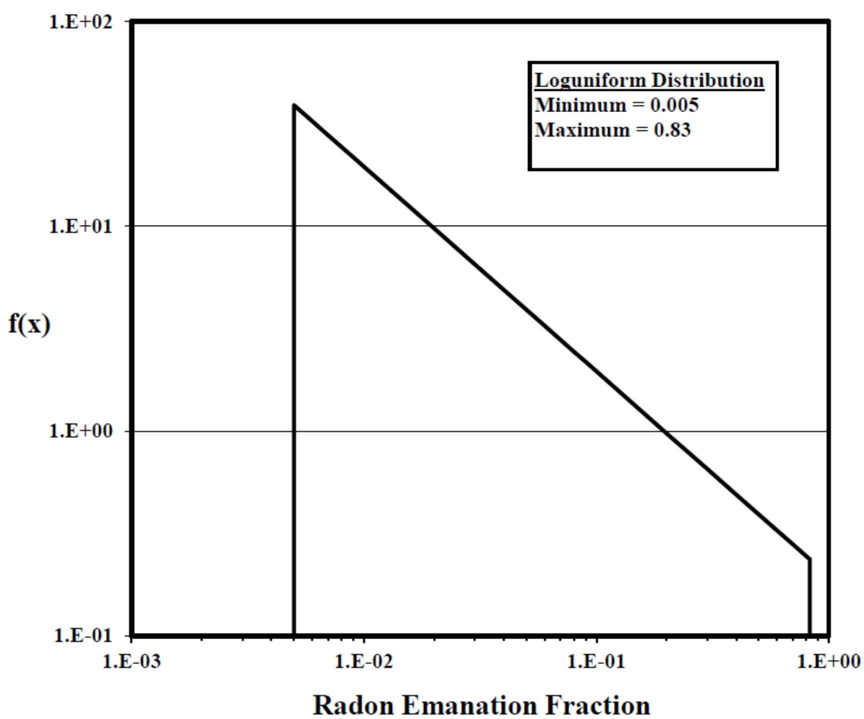

Figure C-75 Radon Emanation Coefficient Probability Density Function

C.8.11 Radon Diffusion Coefficient

Applicable Code: RESRAD-BUILD, RESRAD-ONSITE and RESRAD-OFFSITE

Description: This parameter represents the diffusivity of radon in air or materials.

Units: m^2/s

Probabilistic Input:

Distribution: loguniform

Defining values for distribution:

Minimum: 6.0E-10 Maximum: 7.2E-06

Discussion: In air, the diffusion of radon gas atoms results from a net migration of radon gas toward the direction of its decreasing concentration. The diffusion of radon in open air can be described by Fick's law, which states that the flux density of the diffusing substance is linearly proportional to its concentration gradient. The diffusion coefficient of radon in air can be expressed as the ratio of the flux and the concentration gradient. In porous materials, the radon effective diffusion coefficient is defined as the ratio of the diffusive flux density of radon across the pore area to the gradient of the radon concentration in the pore or interstitial space. This parameter is used by the codes to calculate the diffusion of radon from the source material and is only applicable to the radon inhalation pathway. Therefore, it is only required as input when radionuclides that decay to radon are entered as part of the source material. For radon diffusion in porous media, the diffusivity for the other isotopes of radon (e.g., radon-220) has been observed to be comparable to that for the isotope radon-222.

The effective radon diffusion coefficient varies over a wide range, depending on the diffusion medium. The upper limit is given by the diffusion coefficient in open air, which is about 1.1E-05 m^2/s (Yu, et al. 2015). At the lower extreme, some low-permeability materials may have diffusion coefficients as low as 6.0E-10 m^2/s [Table 4.1.1 in (Yu, et al. 2015)]. For uranium mill tailings, diffusion coefficient as high as 7.2E-06 is observed (Yu, et al. 2015). In general, the effective diffusion coefficient approaches its upper limit for fibrous insulation material and its lower limit for relatively impermeable materials or membranes, such as metals or sealants. Additional information on the radon effective diffusion coefficient can be found in the Data Collection Handbook (Yu, et al. 2015).

In RESRAD-BUILD code, each time a volume source is selected, if the source contains a radionuclide that is a radon precursor, the user must enter a radon effective diffusion coefficient in units of square meters per second (m^2/s). Effective diffusion coefficients are material dependent and must be entered for each layer of each volume source considered. Setting a value of 0 for the radon diffusion coefficient in any uncontaminated layer of a volume source effectively suppresses the flux of radon through that layer until that layer has eroded, thereby rendering the input of other radon-related parameters for that layer inconsequential. In RESRAD-ONSITE and RESRAD-OFFSITE code, the user is requested to enter an effective diffusion coefficient of radon in units of m^2/s for three materials: (1) the soil of the cover zone, (2) the soil of the contaminated zone, and (3) building foundation material (i.e., concrete). Since the effective radon diffusivity values in porous media (soils and concrete included) vary over a wide range of several orders of magnitude, a loguniform distribution is assigned, with minimum and maximum values of 6.0E-10 m^2/s and 7.2E-06 m^2/s, respectively. Figure C-76 presents the probability density function for the radon effective diffusion coefficient.

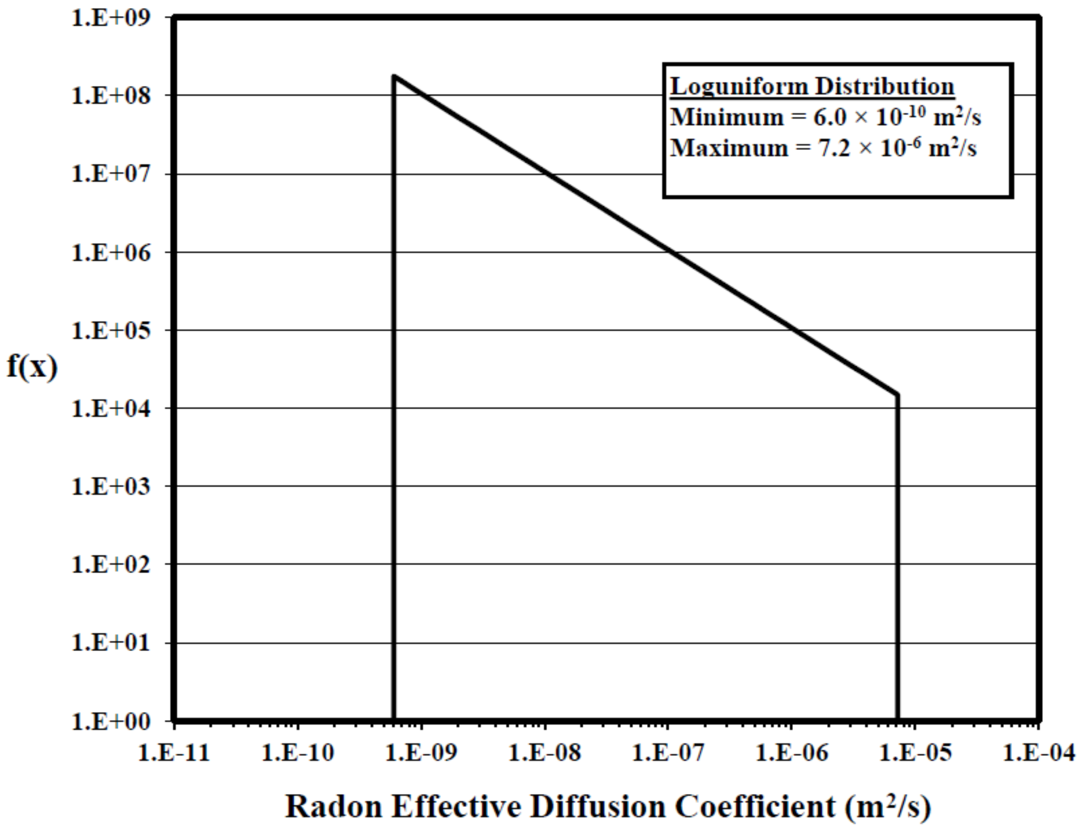

Figure C-76 Radon Effective Diffusion Coefficient Probability Density Function

C.8.12 Soluble Concentration of Nuclides

Applicable Code: RESRAD-OFFSITE

Description: The solubility limit describes the maximum concentration of an element dissolved in an aqueous solution at equilibrium for a given chemical condition, i.e., it is the sum of concentrations of all dissolved substances containing that element. It generally depends on pH, redox potential (Eh), the presence of complexing agents, and the quantity of the co-ion that forms the sparingly soluble compound. For some radionuclides, after releasing from the waste matrix, their dissolution may be limited under specific conditions. At equilibrium the rate of precipitation is equal to the rate of dissolution.

Units: g atomic weight (mol)/L

Probabilistic Input:

Distribution: none recommended

Discussion: It is not easy to measure solubility limits for each radionuclide under in-situ conditions. The common approach used is to perform geochemical equilibrium calculations using geochemical computer codes with thermodynamic database to estimate solubility. For this one uses the chemical composition of the pore water representative of the environment under study, identifies the potential solubility controlling phases in the database, and calculation of the concentration limits for the identified phases. The oxide, carbonate, sulfide, phosphate, or hydroxide compounds represent potential solubility limiting phases. Very few experimental studies are found that have measured solubility limits under in-situ conditions (Felmy et al. 2003, Layton 2016).

Several sources contribute to the uncertainty in the solubility estimates, e.g., uncertainty in thermodynamic data, choice of solubility controlling phase, and uncertainty in the chemical conditions of the pore fluid in which solubility controlling phase is dissolving. Site-specific values based on the geochemical environment of the disposal unit should be used in the dose assessment. The solubility limit should account for the evolution of the geochemistry of the disposal unit during the assessment period.

Table C-102 gives the range of solubility limit from the literature data compiled from different performance assessment studies. However, some geochemical conditions may result in very different soluble concentrations.

Table C-102 Soluble Concentrations in Different Environmental Conditions

Element	Range (mole/L)	References
Ac	1.0E-9 – 1.2E-3	Salah and Wang 2014, Layton 2016
Ag	3.7E-13 – 2.4E-3	Salah and Wang 2014, Mireia et al. 2010
Al	2.4E-03	IAEA 2004
Am	2.4E-8 – 1.0E-2	Salah and Wang 2014, Mireia et al. 2010
B	1.0E-02	IAEA 2004
Ba	1.0E-5 – 3.0E-5	IAEA 2004, Layton 2016
Be	8.5E-17 – 9.9E-5	Salah and Wang 2014, IAEA 2004
C	2.0E-6 – 1E-3	IAEA 2004, Layton 2016
Ca	3.2E-5 – 1E-2	Salah and Wang 2014, IAEA 2004
Cd	2.6E-06	IAEA 2004
Cl	Very soluble	IAEA 2004, Salah and Wang 2014
Cm	1.0E-9 – 1.2E-3	Salah and Wang 2014, Mireia et al. 2010, Layton 2016
Co	3.0E-9 – 1E-3	IAEA 2004
Cr	3.0E-9 – 5E-6	IAEA 2004

Table C-102 Soluble Concentrations in Different Environmental Conditions (cont.)

Element	Range (mole/L)	References
Cs	1.80E-14 – very soluble	Felmy et al. 2003, Salah and Wang 2014, Mireia et al. 2010
Cu	1.0E-07	IAEA 2004
Eu	3.0E-8 – 8.0E-7	Layton 2016
F	4.0E-04	IAEA 2004
Fe	4.8E-12 – 1.5E-4	IAEA 2004
Ga	7.7E-11 – 2.1E-8	IAEA 2004
H	Very soluble	IAEA 2004
Hf	Insoluble	IAEA 2004
Hg	8.8E-13 – 2.0E-4	IAEA 2004
Ho	2.4E-8 – 1.3E-3	Mireia et al. 2010
I	Very soluble	IAEA 2004, Salah and Wang 2014
K	Very soluble	IAEA 2004
Mn	3.2E-6 – 1.3E-3	IAEA 2004
Mo	2.0E-13 – very soluble	Salah and Wang 2014, IAEA 2004
N	Very soluble	IAEA 2004
Na	Very soluble	IAEA 2004
Nb	1.0E-18 – 1.0E-3	Salah and Wang 2014, Mireia et al. 2010
Ni	2.0E-9 – 2.0E-4	Salah and Wang 2014, Mireia et al. 2010, IAEA 2004, Layton 2016
Np	1.8E-18 – 1.0E-3	Salah and Wang 2014, Mireia et al. 2010, Layton 2016
P	1.3E-04	IAEA 2004
Pa	7.9E-35 – 4.0E-4	Mireia et al. 2010
Pb	2.7E-15 – 4.5E-3	Mireia et al. 2010, IAEA 2004
Pd	7.9E-35 – 1.0E-5	Mireia et al. 2010, IAEA 2004
Pt	Insoluble	IAEA 2004
Pu	2.6E-14 – 1.4E-4	Salah and Wang 2014, Mireia et al. 2010, Layton 2016
Ra	8.5E-12 – 1.2E-4	Salah and Wang 2014, Mireia et al. 2010, Layton 2016, Felmy et al. 2003
Rb	Very soluble	Salah and Wang 2014
Sb	1.0E-04	IAEA 2004
Se	6.6E-12 – 2.4E-6	Salah and Wang 2014, Mireia et al. 2010

Table C-102 Soluble Concentrations in Different Environmental Conditions (cont.)

Element	Range (mole/L)	References
Si	1.3E-7 – 1.3E-5	IAEA 2004
Sm	3.7E-13 – 3.7E-4	Salah and Wang 2014, Mireia et al. 2010, SRR (2016)
Sn	1.1E-8 – 5.0E-3	Salah and Wang 2014, Mireia et al. 2010, IAEA 2004, Layton 2016
Sr	4.7E-6 – 3.0E-3	Salah and Wang 2014, Mireia et al. 2010, IAEA 2004, Layton 2016
Tc	2E-15 – 4.6E-7	Salah and Wang 2014, Mireia et al. 2010, Layton 2016
Th	3.2E-9 – 3.2E-8	Felmy et al. 2003
Ti	Insoluble	IAEA 2004
U	4.5E-13 – 3.0E-2	Salah and Wang 2014, Mireia et al. 2010, IAEA 2004, Layton 2016, Felmy et al. 2003
W	Very soluble	IAEA 2004
Y	4.0E-13 – 2.0E-9	Layton 2016
Zn	1.0E-03	IAEA 2004
Zr	3.5E-10 – 1.1E-4	Salah and Wang 2014, Mireia et al. 2010, IAEA 2004, Layton 2016, Felmy et al. 2003

C.8.13 Diffusion Coefficient of Nuclides

Applicable Code: RESRAD-OFFSITE

Description: The required input is the diffusion coefficient which is used to calculate flux of radionuclides across the surfaces of a waste matrix where radionuclides distribute homogeneously. It characterizes the flux of a specific radionuclide within a unit time with respect to concentration gradient of that radionuclide in pore water in the direction of radionuclide movement.

Units: m^2/yr

Probabilistic Input:

Distribution: none

Discussion: This parameter is used by the RESRAD-OFFSITE source term model to evaluate diffusive release of radionuclides from the waste domain to the surrounding soil domain. Radionuclides are considered to distribute homogeneously in the waste matrix, which is porous. It is assumed that the pores are small and flow of water through the waste matrix is restricted. Therefore, after water infiltrates the waste matrix, radionuclides that partition to the water would diffuse throughout the waste matrix. Radionuclides diffuse across the boundary of the waste matrix into the surrounding soil. The radionuclides then partition to soil water and transport to deeper soils. The following equation (C-32) governs the diffusive transport of a radionuclide in the waste matrix with a rectangular coordinate system:

$$\frac{\partial C_{aq}}{\partial t} = \frac{\theta D}{\theta + \rho_b K_d}\left(\frac{\partial^2 C_{aq}}{\partial x^2} + \frac{\partial^2 C_{aq}}{\partial y^2} + \frac{\partial^2 C_{aq}}{\partial z^2}\right) - \lambda C_{aq} \tag{C-32}$$

where

C_{aq} = concentration of radionuclide in pore water (pCi/cm^3),

t = time (yr),

θ = volumetric water content in the waste matrix (untiless),

D = diffusion coefficient (m^2/yr),

ρ_b = dry bulk density of the waste matrix (g/cm^3),

K_d = distribution coefficient of radionuclide between the solid and pore water of the waste matrix (cm^3/g),

x, y, z = coordinate in the x, y, and z direction (m), and

λ = radiological decay constant of radionuclide (1/yr).

The effective diffusion coefficient, D_e, is related to the diffusion coefficient, D

$$D_e = \frac{\theta D}{\theta + \rho_b K_d} \tag{C-33}$$

By combining equation (C-32) and equation (C-33), equation (C-34) is obtained:

$$\frac{\partial C_{aq}}{\partial t} = D_e\left(\frac{\partial^2 C_{aq}}{\partial x^2} + \frac{\partial^2 C_{aq}}{\partial y^2} + \frac{\partial^2 C_{aq}}{\partial z^2}\right) - \lambda C_{aq} \tag{C-34}$$

Other parameters that are also used in evaluating diffusive release include total mass, total volume, volumetric water content, and distribution coefficient (K_d) of the contaminated medium, i.e., the waste matrix, as well as the length, width, and depth of the effective dimensions of the waste matrix for considering diffusion (i.e., dimensions of individual fragment of contaminated medium for diffusion). The first four parameters are used to determine the concentration of the radionuclide of concern in the pore water (Caq) assuming instantaneous equilibrium, when there is contact of waste medium with water. Based on the concentration in pore water, and the dimensions (assumed of a 3-D rectangular shape) in which the diffusion takes place, the concentration gradients in the x-, y-, z-directions are calculated. (Note: The concentration profiles of radionuclides from the center to both directions of the x-, y-, and z- axes are considered to be symmetrical.) The concentration gradient at the edge of the dimensions for diffusion is then multiplied by the effective diffusion coefficient to estimate the flux of radionuclide. The multiplication of the flux and the surface area it crosses gives the release rate of radionuclide from that surface. The sum of the diffusion release rates from the six surfaces give the total release rate of radionuclide to the soil domain.It should be noted that the effective dimensions of the waste matrix for considering diffusion could be different from the dimensions of the waste matrix container (or waste form). For example, cement-grouted wastes in disposal containers have tiny pore space or micro-cracks in the cement matrix which would restrict the flow of water. If the integrity of the cement matrix does not deteriorate further under contact with water, the cement matrix as a whole would be the domain for diffusion. This is because there are no large cracks formed within the cement matrix where water can flow in and out and radionuclides can migrate to leave the container by advection. As a result, radionuclides in cement pore water would need to diffuse to the edge of the cement matrix to leave the container. Under such conditions, the cement matrix is the single fragment for diffusion. If the cement matrix deteriorates further to form large cracks, then the entire matrix could be divided into multiple fragments and each fragment could be a domain for diffusion. Under such conditions, radionuclides just need to diffuse to the large cracks where they could migrate to the edge of the cement matrix by advection to leave the container. Both the diffusion and the advection process would affect the release rate of radionuclides from the container, but most likely, the diffusion process would have greater influence, because in general, diffusion proceeds much more slowly and would produce a smaller flux of radionuclide than would advection. The dimensions of individual fragments for modeling the diffusive release would be smaller than the dimensions of the cement matrix when there are large cracks, and the values would need to be determined by considering the extent of deterioration of the cement matrix. Given the same radionuclide concentration in the waste matrix, the diffusive release rate would be greater if the dimensions of individual fragments for diffusion are smaller.

Various laboratory methods are used to measure effective diffusion coefficients, which are different for different radionuclides. The value for a radionuclide is dependent on its chemical form, the waste matrix material and the chemical compounds it contains, the porosity, size of pores or micro-cracking, and the water content in the waste matrix, the temperature at which diffusion occurs, etc. The laboratory methods usually involve immersing a volume of the waste form material (with known surface area) containing the radionuclide of concern with known radioactivity in a pool of water, measuring water concentration at different times, and fitting a theoretical equation predicting the water concentration based on diffusive release with the measurement data. Because the release of radionuclides could be facilitated by more than one interactions, it is important to verify that diffusion is the rate-controlling mechanism in order to obtain a meaningful value for effective diffusion coefficient from the data fitting. Two standard test methods are commonly used, ANSI-16.1 (Measurement of the Leachability of Solidified Low-Level Radioactive Wastes by A Short-Term Procedure), and ASTM C1308 (Standard Test Method for Accelerated Leach Test for Diffusive Releases from Solidified Waste and a Computer Program to Model Diffusive, Fractional Leaching from Cylindrical Waste Forms). To use the measured effective diffusion coefficient in RESRAD-OFFSITE, enter the measured value (after unit conversion, if necessary) as the diffusion coefficient for the contaminated medium, and set the distribution coefficient (K_d) in the contaminated medium to 0.

Literature data on effective diffusion coefficient obtained from different sources all focus on cement/concrete as the waste matrix. The collected data were pooled together to identify the range of the parameter value, if possible, as listed in the following table, otherwise, the reported values are listed for reference.

Table C-103 Compilation of Literature Data on Effective Diffusion Coefficient in Cement/Concrete Matrix for Different Elements

Element	Effective Diffusion Coefficient (cm^2/s)	Effective Diffusion Coefficient (m^2/yr)	Data source
Ac	5.0E-11	1.6E-07	Sullivan, 2004
Ag	5.0E-11	1.6E-07	Sullivan, 2004
Am	5.0E-13	1.6E-09	Sullivan, 2004
C (as carbonate)	1.0E-12	3.2E-09	Sullivan, 2004
Cm	5.0E-11	1.6E-07	Sullivan, 2004
Co	4.0E-15–5.0E-11	1.3E-11–1.6E-07	Muurinen, 1983; Mattigood, 2002; Sullivan, 2004
Cs	2.7E-15–3.0E-09	8.5E-12–9.5E-06	Atkinson, 1986; Atkinson, 1986; Mattigood, 2002; Sullivan, 2004
Eu	1.0E-11–5.0E-11	3.2E-08–1.6E-07	Serne, 1992; Sullivan, 2004
Fe	5.0E-11	1.6E-07	Serne, 1992; Sullivan, 2004
H	6.0E-9–5.5E-7	1.9E-05–1.7E-03	Matsuzuro, 1979; Szanto, 2002; Sullivan, 2004
I	7.9E-15–2.6E-9	2.5E-11–8.2E-06	Mattigod, 2001, 2012; Mann, 2005
Nb	5.0E-11	1.6E-07	Sullivan, 2004
Ni	5.0E-10	1.6E-06	Sullivan, 2004
Np (V)	5.0E-10	1.6E-06	Sullivan, 2004
Pa	5.0E-08	1.6E-04	Sullivan, 2004
Pb	1.0E-11	3.2E-08	Sullivan, 2004
Pu	5.0E-11	1.6E-07	Sullivan, 2004
Ra	5.0E-11	1.6E-07	Sullivan, 2004
Re	3.8E-12–2.0E-09	1.2E-8–6.3E-6	Mattigod, 2012
Sr	1.0E-11–5.2E-10	3.2E-08–1.6E-06	Sullivan, 1988; Sullivan, 2004
Tc	1.8E-13–1.0E-08	5.7E-10–3.2 E-05	Mattigod, 2001, 2012; Sullivan, 2004; Mann, 2005
Th	1.0E-12	3.2E-09	Sullivan, 2004
U	1.0E-12	3.2E-09	Sullivan, 2004

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NRC FORM 335 (12-2010) NRCMD 3.7

U.S. NUCLEAR REGULATORY COMMISSION

BIBLIOGRAPHIC DATA SHEET

(See instructions on the reverse)

1. REPORT NUMBER **(Assigned by NRC, Add Vol., Supp., Rev., and Addendum Numbers, if any.)**
NUREG/CR-7267

2. TITLE AND SUBTITLE
Default Parameter Values and Distribution in RESRAD-ONSITE V7.2, RESRAD-BUILD V3.5, and RESRAD-OFFSITE V4.0 Computer Codes

3. DATE REPORT PUBLISHED

MONTH	YEAR
June	2024

4. FIN OR GRANT NUMBER

5. AUTHOR(S)
S. Kamboj, E. Gnanapragasam, J.-J. Cheng, D. LePoire, C. Wang, B. Biwer, and C. Yu

6. TYPE OF REPORT

7. PERIOD COVERED (Inclusive Dates)

8. PERFORMING ORGANIZATION - NAME AND ADDRESS (If NRC, provide Division, Office or Region, U. S. Nuclear Regulatory Commission, and mailing address; if contractor, provide name and mailing address.)
Argonne National Laboratory
9700 S. Cass Avenue
Argonne, IL 60439

9. SPONSORING ORGANIZATION - NAME AND ADDRESS (If NRC, type "Same as above", if contractor, provide NRC Division, Office or Region, U. S. Nuclear Regulatory Commission, and mailing address.)
Office of Nuclear Regulatory Research
United States Nuclear Regulatory Commission
U.S. Nuclear Regulatory Commission
Washington, DC 20555-0001

10. SUPPLEMENTARY NOTES

11. ABSTRACT (200 words or less)
This report provides updated information on the default parameter values and parameter distributions contained in the RESRAD family of codes since the release of the probabilistic RESRAD-ONSITE Version 6.0 (formerly called RESRAD 6.0), RESRAD-OFFSITE Version 2.0, and RESRAD-BUILD Version 3.0 (Yu et al. 2000, 2007). This report also discusses changes made in the family of RESRAD codes since 2002. All three codes are pathway analysis models designed to evaluate the potential radiological dose incurred by an individual who lives at a site with radioactively contaminated soil or who works in a building containing residual radioactive material.

12. KEY WORDS/DESCRIPTORS (List words or phrases that will assist researchers in locating the report.)
default parameter values, parameter distributions, RESRAD family of codes, probabilistic RESRAD-ONSITE Version 6.0, RESRAD-OFFSITE Version 2.0, RESRAD-BUILD Version 3.0, radioactively contaminated soil, building containing residual radioactive material

13. AVAILABILITY STATEMENT
unlimited

14. SECURITY CLASSIFICATION
(This Page)
unclassified
(This Report)
unclassified

15. NUMBER OF PAGES

16. PRICE

UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, DC 20555-0001

OFFICIAL BUSINESS

NUREG/CR-7267

Default Parameter Values and Distribution in RESRAD-ONSITE V7.2, RESRAD-BUILD V3.5, and RESRAD-OFFSITE V4.0 Computer Codes

June 2024