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Model Parameters for the Clive DU PA Model

Clive DU PA Model v1.2

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Prepared by

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1. Title: Model Parameters for the Clive DU PA Model		
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3. Description: This white paper provides documentation of all the parameters in the Clive DU PA Model and references for their values and input distributions.		
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6. Remarks		

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1.0 Introduction

This document, along with the complementary Excel workbook, Clive PA Model Parameters.xls, is a collection of all the input parameters used in the Clive DU PA GoldSim model. The workbook contains those parameters that are most conveniently stored in arrays (such as collections of values by contaminant Species or by chemical Elements), and this document contains individual parameter values and distributions, organized by Containers in the model. Expressions and other operators that do not have model inputs are not represented in these documents. Some input distributions refer to other expression for part of their specification. Rather than writing in those expressions, these are generally noted here as simply “$f(x)$”.

2.0 Distribution Specification

Distributions in this document are specified according to the notation shown in Table 1.

Table 1. Statistical distribution types used in the parameter specifications.

distribution type	value or distribution
discrete	value
uniform	U(minimum, maximum)
log uniform	LU(minimum, maximum)
triangular	Tri(minimum, expected, maximum)
normal	N(mean μ, standard deviation σ)
truncated normal	N(mean μ, standard deviation σ, minimum, maximum)
log-normal	LN(geometric mean GM, geometric standard deviation GSD)
truncated log-normal	LN(GM, GSD, minimum, maximum)
beta (generalized)	beta(mean μ, standard deviation σ, minimum, maximum)
Weibull	W(minimum, Weibull slope, mean - minimum)

3.0 \SimulationSettings

The SimulationSettings container has two primary subcontainers, Chronology and Switches. A standard set of simulation settings is suggested in order to control intercomparisons between various runs. The standard set includes Simulation Settings and the values of the various Switches.

Table 2. Generic constants used in simulations

GoldSim element	value	units	reference / comment
Small	1×10^{-30}	—	arbitrarily small number for use in modeling constructs
Large	1×10^{30}	—	arbitrarily large number for use in modeling constructs
U_mask	vector by species of 1's for U species, 0's for non-U species		Modeling construct: All uranium isotopes have a value of 1, and all other radionuclides have a value of 0.

3.1 Simulation Settings (the GoldSim dialog)

The GoldSim Simulation Settings dialog (accessed through the F2 key, or from the menu as Run | Simulation Settings...) controls a number of settings controlling the probabilistic and deterministic modeling runs (Table 3) as well as the specification of time steps (Table 4). Time steps are specific so that values of time-varying outputs are recorded at various times during the simulation. These values, the saving of which is identified by checking the "FV" column, are then available for post-processing analysis. Users of GoldSim are able to modify these time steps, but GoldSim Player users may not. Do not modify the 2500-yr time step length in the later time steps, as these are assumed to exist for the deep time assessment.

If the user desires to run a shorter simulation than the full 2.1 My, this should be done using the model's Control Panel dashboard—not by entering in a shorter duration in the Simulation Settings dialog. See the *Clive PA Model User Guide* for more details on the use of model controls and dashboards.

Table 3. Monte Carlo simulation settings

setting	value	comments
Time		
Time Display Units	yr	This is a fixed model setting.
Duration	21000000 yr	2.1 million years is required for U-238 to reach secular equilibrium with its decay products.
Start-time / End-time	—	These are ignored.
Probabilistic Simulation		
# Realizations	variable	Set by user.
# Histories to save	variable	Set to # Realizations for viewing all realizations; set to zero for sensitivity analysis.

setting	value	comments
Use Latin Hypercube Sampling	checked	Use of LHC sampling is advisable in order to evenly sample distributions.
Repeat Sampling Sequences	checked	Check to ensure reproducibility.
Random Seed	variable	This is a user-selected value.
Deterministic Simulation		
Solve Simulation deterministically using:	Element Deterministic Values	

The Time Phase Settings are set on the Time tab of Simulation Settings. The table of values is shown below, but there are also related settings accessed with the Advanced... button. These settings should be as follows:

Uncheck “Allow events to occur between timesteps”

Check “Allow dynamic reduction in timestep length”, and set “Maximum timestep length to allow:” to be if(ETime < 10 yr then 0.1 yr else if(ETime < 1e5 yr then 40 yr else 1000 yr)).

Set “Time to use for Edit Model updates:” to 0 s.

Table 4. Times Phase Settings for the full 2.1-million year run

time range (y)	# steps	time step length (y)	plot every	FV
0 - 1	10	0.1	10	
1 - 10	9	1	9	
10 - 100	18	5	2	
100 - 1000	45	20	1	
1000 - 10000	36	250	2	X
10000 - 100000	36	2500	2	
100000 - 2100000	800	2500	4	X

3.2 \SimulationSettings\Chronology

The model chronology is documented in this container, referenced throughout the model (Table 5).

Table 5. Global events and their probability of occurrence

GoldSim element	value or distribution	units	reference / comment

GoldSim element	value or distribution	units	reference / comment
ModelTimeZero time at which calculations start	2012		Assumed date for first disposal of DU in the Class A South embankment.
IC_Period time since time zero of loss of institutional control	discrete, 100	yr	Assumed duration of active institutional control, per regulatory language.
CapNaturalization_Time time since time zero to when the cap is fully naturalized	discrete, 1	yr	Assume the ET Cover becomes naturalized at the beginning of the simulation.
Dose_Simulation_Duration time since time zero that dose	user-selected	yr	User can set this value, up to 10,000 yr, per UAC R313-28-8

3.3 \SimulationSettings\Switches

Switches that control the model are not model inputs documented here, as they are user-selectable via the Control Panel and other dashboards.

4.0 \Materials

Most of the Species-specific properties are defined in the Excel workbook, Clive DU PA Model Parameters.xls, since they are tabulated lists and therefore better suited to a spreadsheet format from which values can be electronically transferred to the model. A number of parameters, however, as well as the overall decay chain scheme, are presented in the decay chain diagrams, shown in Figure 1 and Figure 2. Radionuclides in black are modeled for contaminant transport and dose contributions, those in green are modeled for dose contributions only, and those in gray are not modeled. Figure 3 shows details of those actinide decay chains where some radionuclides are omitted from the model calculations. These are radionuclides with exceedingly small branching fractions and/or no dose conversion factors, so they could not possibly affect model results or decisions based on those results.

One value defined for each contaminant species in the Species element cannot be referenced to an array: the molecular (or in this case, atomic) mass, also called the molecular or atomic weight. GoldSim assumes the same atomic mass for all isotopes for a given chemical element. For example, all isotopes of uranium are assigned the atomic mass of the first isotope encountered — ^{232}U in this case. Therefore, the atomic masses shown in Table 6 are defined for each element, not for each radionuclide. These values are entered manually into the Species element in the \Materials container of the model. In all cases, the most abundant isotope is used, based on inventory mass as developed in \Inventory\Total_DU_Inventory for disposed radionuclides, and the corresponding decay products for radionuclides that ingrow. For example, the disposed mass of thorium is reported as zero, but since most of the thorium would be ingrowing from the large mass of ^{238}U, the corresponding thorium isotope of greatest mass would be ^{230}Th. This ignores the half-life of the decay products, but any error in averaged or presumed atomic masses is expected to be quite minor, since ^{230}Th and ^{232}Th have very similar atomic masses anyway.

Table 6. Atomic mass of Species

Species ID	atomic mass (g/mol)	Species ID	atomic mass (g/mol)
Sr90	90	Ac227	227
Tc99	99	Th228, Th229, Th230, Th232	230
I129	129	Pa231	231
Cs137	137	U232, U233, U234, U235, U236, U238	238
Pb210	210	Np237	237
Rn222	222	Pu238, Pu239, Pu240, Pu241, Pu242	239
Ra226, Ra228	226	Am241	241

Other chemical elements used in the model have their atomic masses listed in Table 7.

Table 7. Atomic masses of other elements

GoldSim element	value or distribution	units	reference / comment
Fluorine_AtomicMass	19.0	g/mol	Chart of the Nuclides, 16th Edition
Oxygen_AtomicMass	16.0	g/mol	*ibid.*

4.1 \Materials\DecayChains

Decay chains are illustrated in this container and reproduced below in Figures 1 through 3.

Decay chains implemented in contaminant transport and dose calculations

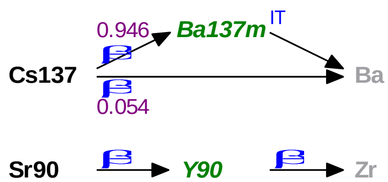
Note that the radionuclides and stable nuclides in black are maintained in the Species list. Any modification to the decay chain diagram needs to have an associated modification to the Species list, and vice versa.

The radionuclides noted in green italic are considered in the dose assessment only, through dose coversion factors. Environmental transport of these progeny is assumed to follow their respective parents, with which they are in secular equilibrium.

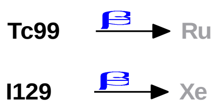
Radionuclides, stable nuclides, and decay arrows in gray are not represented in the model, but are shown here for completeness. Details in the Actinide_detail Container are also not modeled.

These decay chains are based on the branching fractions in the Nuclear Wallet Cards (Tuli, 2005), except that for Cs137, which is based on Kocher (1981). Unless noted at a branch, the branching fraction is always 1. Alpha decay is indicated by a red arrow. In a few cases, complex decay paths have been simplified, and are shown in the detail Container. These cases are invariably inconsequential, as the branching fractions in question are extremely small.
Revised 25 March 2014 - JT

Non-actinoid decay to dose-producing progeny:



Non-actinoid decay to stable progeny that are not modeled:



Neptunium Series, simplified

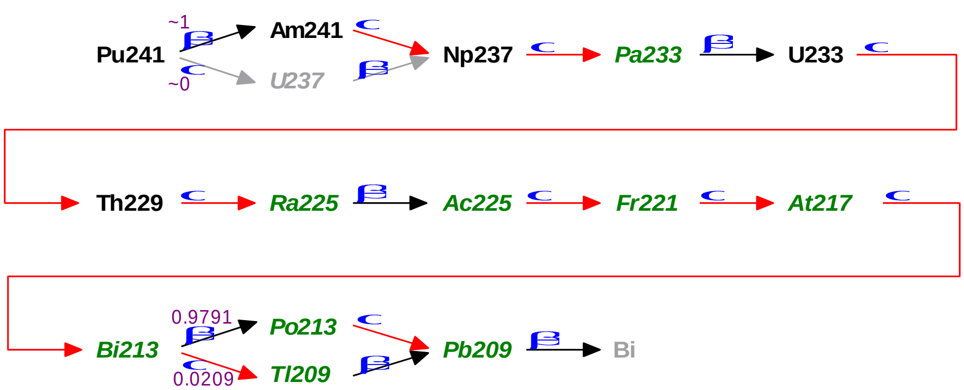


Figure 1. Decay chains modeled in the Clive DU PA Model, part 1 of 2.

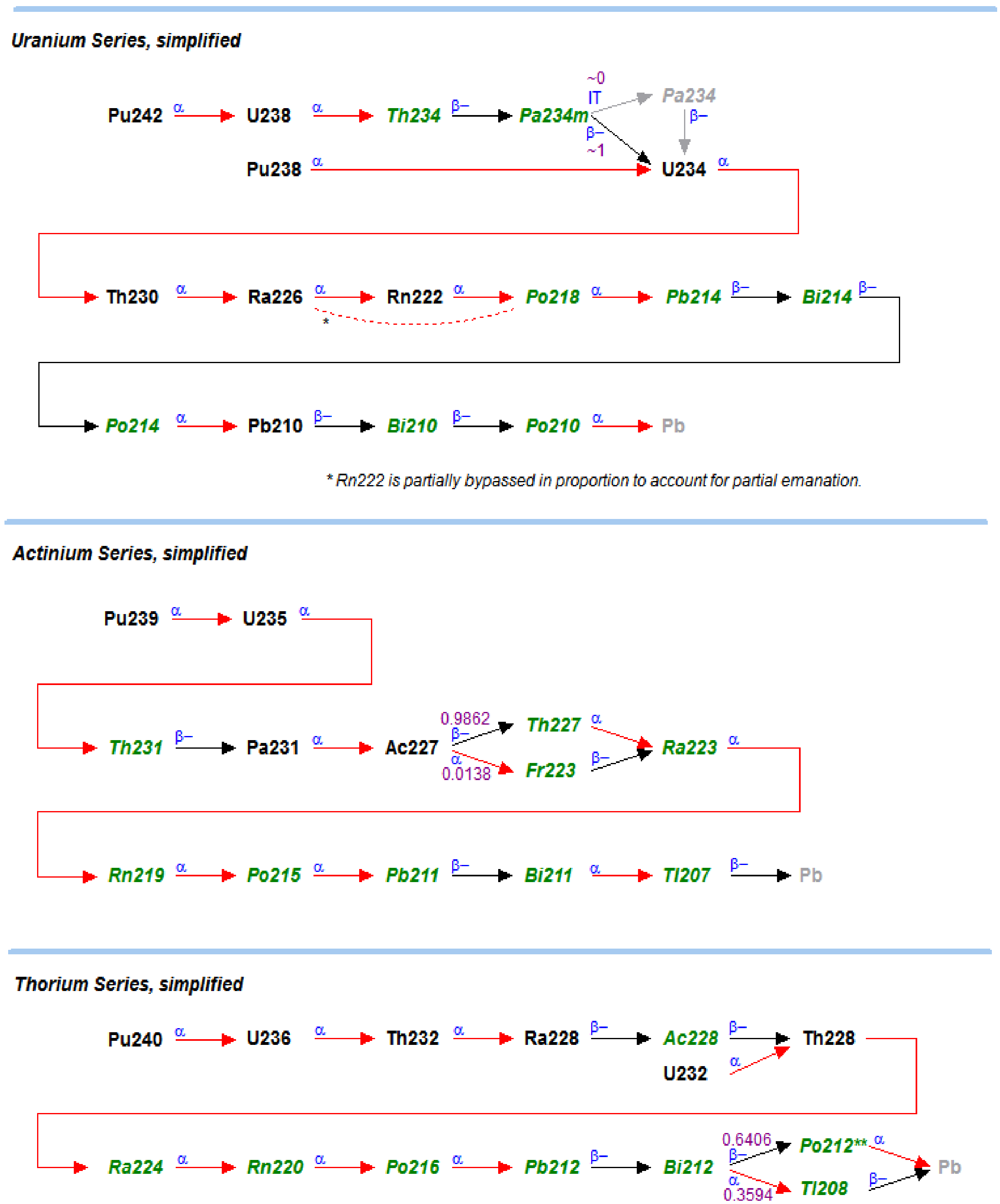


Figure 2. Decay chains modeled in the Clive DU PA Model, part 2 of 2.

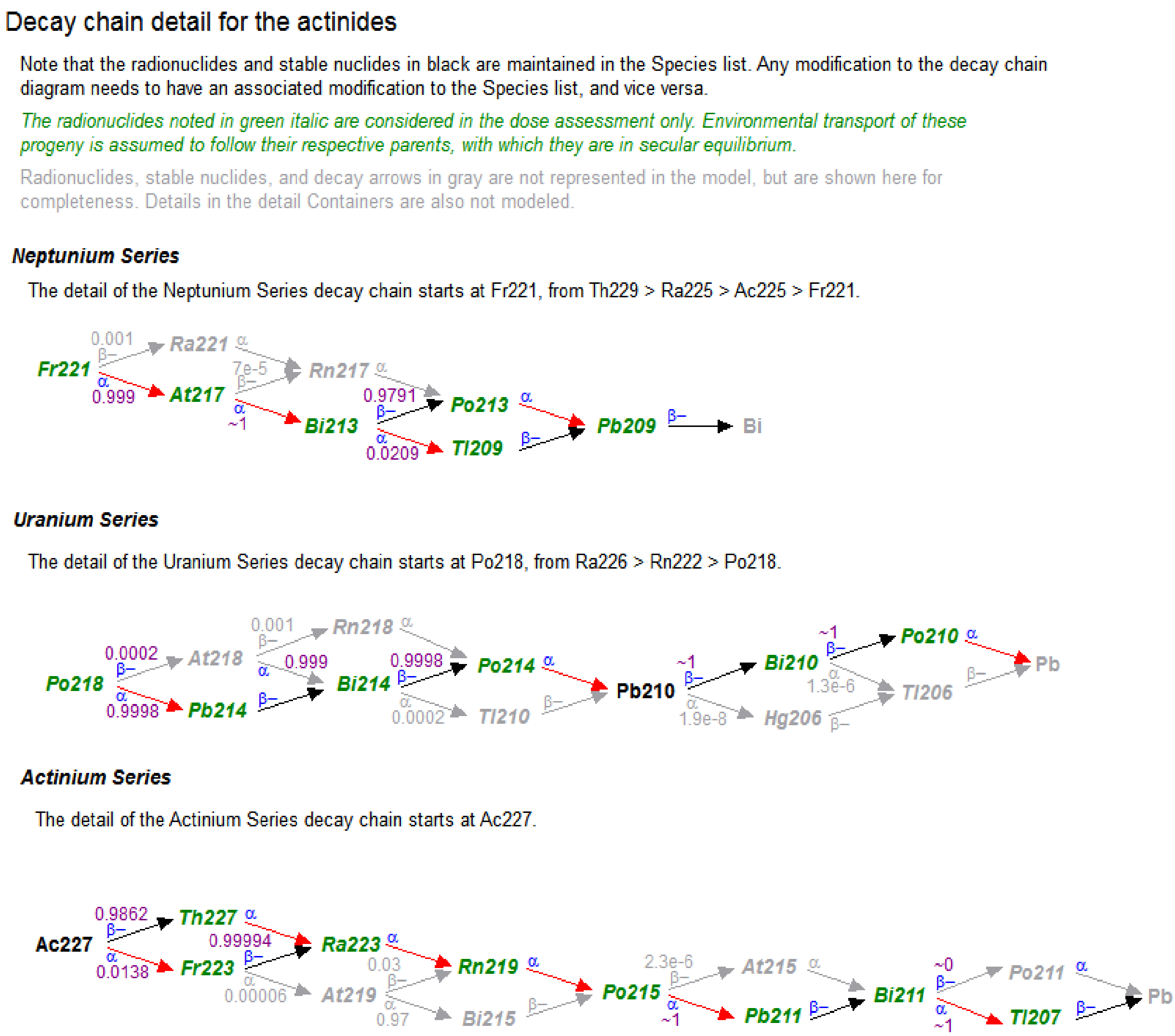


Figure 3. Details of the actinide decay chains modeled in the Clive DU PA Model, showing which species are omitted, in gray.

4.2 \Materials\Loess_Properties

Since loess (windblown sediment) is derived from the surrounding Unit 4 surface soils, the material properties for Loess are redirected to those of Unit 4 (see Table 8).

4.3 \Materials\Unit4_Properties

Unit 4 is a silty clay, the uppermost unit deposited in the region by ancestral lakes. Windblown loess that deposits in the upper cover layers is derived from Unit 4, and shares its material properties. This is also used for a source material for certain parts of the engineered system (clay liner and upper and lower radon barriers), and has materials properties listed in Table 8. Unit 4 is also used for the basic material properties of the clay liner and the upper and lower radon barrier clay layers. Unit 4 is assigned K_d values for silt.

Table 8. Unit 4 material properties

GoldSim element	value or distribution	units	reference / comment
ParticleDensity_Unit4 particle density of Unit 4 material	2.65	g/cm^3	see Unsaturated Zone Modeling white paper
Porosity_Unit4 porosity of Unit 4 material	N(μ=0.428, σ=6.08e-3, min=Small, max=1-Small)	—	*ibid.*, truncated just above 0 and just below 1
BulkDensity_Unit4 dry bulk density of Unit 4 material	N(μ =$f(x)$, σ=0.1, min=Small, max=Large)	g/cm^3	*ibid.*, truncated just above 0
D_Unit4 Brooks-Corey fractal dimension parameter for Unit 4 material	N(μ=2.81, σ=9.93e-5, min=0, max=3)	—	*ibid.*, truncated at 0 and 3
Hb_Unit4 bubbling pressure head of Unit 4 material	N(μ=104., σ=1.72, min=Small, max=Large) correlated to D_Unit4 as -0.66	cm	*ibid.*, truncated just above 0
MCres_Unit4 residual moisture content for Unit 4 material	N(μ=0.108, σ=8.95e-4, min=Small, max=Large)	—	*ibid.*, truncated just above 0
Ksat_Unit4 saturated hydraulic conductivity for Unit 4 material	N(μ=5.16e-5, σ=5.97e-7 , min=Small, max=Large) correlated to D_Unit4: -0.37	cm/s	*ibid.*, truncated just above 0
log_vG_Alpha	N(μ=-1.79, σ=0.64, min=-Large, max=0)	—	*ibid.*, truncated at 0
log_vG_n	N(μ=0.121, σ=0.1, min=0, max=Large)	—	*ibid.*, truncated at 0

4.4 \Materials\Unit3_Properties

Material properties for the unsaturated zone below the liner of the disposal embankment, comprised of stratigraphic Unit 3, a silty sand, are provided in Table 9. Unit 3 is assigned K_d values for sand.

Table 9. Unit 3 material properties

GoldSim element	value or distribution	units	reference / comment
ParticleDensity_Unit3 particle density of Unit 3 material	2.65	g/cm^3	see Unsaturated Zone Modeling white paper
Porosity_Unit3 porosity of Unit 3 material	N(μ=0.393, σ=6.11e-3, min=Small, max=1-Small)	—	*ibid.*, truncated just above 0 and just below 1
BulkDensity_Unit3 dry bulk density of Unit 3 material	N(μ =$f(x)$, σ=0.1, min=Small, max=Large)	g/cm^3	*ibid.*, truncated just above 0
D_Unit3 Brooks-Corey fractal dimension parameter for Unit 3 material	N(μ=2.73, σ=5.21e-3, min=0, max=3)	—	*ibid.*, truncated at 0 and 3
Hb_Unit3 bubbling pressure head of Unit 3 material	N(μ=8.85, σ=0.929, min=Small, max=Large); [*correlated to D_Unit3 -0.85*]	cm	*ibid.*, truncated just above 0
MCres_Unit3 residual moisture content for Unit 3 material	N(μ=6.78e-3, σ=2.05e-3, min=Small, max=Large)	—	*ibid.*
Ksat_Unit3 saturated hydraulic condictivity for Unit 3 material	N(μ=5.14e-5, σ=5.95e-6, min=Small, max=Large); [*correlated to D_Unit3 -0.98*]	cm/s	*ibid.*, truncated just above 0

4.5 \Materials\Unit2_Properties

Material properties for the saturated zone, comprised of stratigraphic Unit 2, a silty clay, are provided in Table 10. Unit 2 is assigned K_d values for clay.

Table 10. Unit 2 material properties

GoldSim element	value or distribution	units	reference / comment
BulkDensity_Unit2 dry bulk density for Unit 2 material	N(μ=1.57, σ=0.05, min=Small, max=Large)	g/cm^3	see Saturated Zone Modeling white paper truncated just above 0
Porosity_Unit2 porosity for Unit 2 material	N(μ=0.29, σ=0.05, min=Small, max=1-Small)	—	*ibid.*, truncated just above 0 and just below 1

GoldSim element	value or distribution	units	reference / comment
Ksat_Unit2 saturated hydraulic conductivity for Unit 2	N(μ=9.6e-4, σ=9.67e-5, min=Small, max=Large)	cm/s	*ibid.*, truncated just above 0

4.6 \Materials\RipRap_Properties

Rip Rap was used to construct the uppermost layer: Armor. It quickly becomes infilled with Loess. The Rip Rap itself is assumed to be an inert material. It is not used in Model v1.2, but it is left in the model for now.

Table 11. Rip rap material properties

GoldSim element	value or distribution	units	reference / comment
ParticleDensity_RipRap	2.65	g/cm^3	see Unsaturated Zone Modeling white paper
BulkDensity_RipRap	N(μ=$f(x)$, σ=0.1, min=Small, max=Large)	g/cm^3	*ibid.*, truncated just above 0
Porosity_RipRap	N(μ=0.18, σ=0.01, min=Small, max=1-Small)	—	*ibid.*, truncated just above 0 and just below 1

4.7 Materials\FineCobbleMix_Properties

Fine Cobble Mix is used to construct the upper filter layer in the Model v1.0. It also becomes quickly infilled with Loess. The Fine Cobble Mix itself is assumed to be an inert material. It is not used in Model v1.2, but it is left in the model for now.

Table 12. Fine cobble mix material properties

GoldSim element	value or distribution	units	reference / comment
ParticleDensity_ FineCobbleMix	2.65	g/cm^3	see Unsaturated Zone Modeling white paper
BulkDensity_ FineCobbleMix	N(μ=$f(x)$, σ=0.1, min=Small, max=Large)	g/cm^3	*ibid.*, truncated just above 0
Porosity_ FineCobbleMix	N(μ=0.19, 0.01, min=Small, max=1-Small)	—	*ibid.*, truncated just above 0 and just below 1

4.8 Materials\SiltSandGravel_Properties

Silt Sand Gravel is used to construct the Sacrificial Soil layer in Model v1.0 and the Frost Protection Layer in Model v1.2.

Table 13. Silt sand gravel material properties

GoldSim element	value or distribution	units	reference / comment
ParticleDensity_ SiltSandGravel	2.65	g/cm^3	see Unsaturated Zone Modeling white paper
BulkDensity_ SiltSandGravel	N(μ=$f(x)$, σ=0.1, min=Small, max=Large)	g/cm^3	*ibid.*, truncated just above 0
Porosity_ SiltSandGravel	N(μ=0.31, 0.01, min=Small, max=1-Small)	—	*ibid.*, truncated just above 0 and just below 1

4.9 Materials\FineGravelMix_Properties

Fine Gravel Mix is used to construct the lower filter layer in Model v1.0. The Fine Gravel Mix itself is assumed to be an inert material. It is used as an inert filler material in the Surface Layer of Model v1.2.

Table 14. Fine gravel mix material properties

GoldSim element	value or distribution	units	reference / comment
ParticleDensity_ FineGravelMix	2.65	g/cm^3	see Unsaturated Zone Modeling white paper
BulkDensity_ FineGravelMix	N(μ=$f(x)$, σ=0.01, min=Small, max=Large)	g/cm^3	*ibid.*, truncated just above 0
Porosity_ FineGravelMix	N(μ=0.28, 0.01, min=Small, max=1-Small)	—	*ibid.*, truncated just above 0 and just below 1

4.10 Materials\UpperRnBarrierClay_Properties

The Radon Barrier layers are divided into upper and lower layers. Both are constructed of local Unit 4 clay, compacted to different hydraulic conductivities. UpperRnClay represents the upper of the two layers, and has significantly lower K_{sat} (see Table 15). Other material properties for this material are redirected to those of Unit 4 (see Table 8).

Table 15. Upper radon barrier clay material properties

GoldSim element	value or distribution	units	reference / comment
UpperRnBarrierKsat_As Built	4e-3	cm/day	see Unsaturated Zone Modeling white paper
RnBarrierKsat_Natdist	LN(0.691, 6.396)	cm/day	*Ibid.*, right shift of 0.00432 is added after a value is pulled from the distribution

4.11 Materials\LowerRnBarrierClay_Properties

The Lower Radon Barrier is constructed of compacted local Unit 4 clay, but has its own K_{sat} (see Table 16). LowerRnClay represents the lower of the two layers. Other material properties for this material are redirected to those of Unit 4 (see Table 8).

Table 16. Lower radon barrier clay material properties

GoldSim element	value or distribution	units	reference / comment
LowerRnBarrierKsat_ Asbuilt	8.6e-2	cm/s	see Unsaturated Zone Modeling white paper

4.12 Materials\LinerClay_Properties

The Liner is constructed of compacted local Unit 4 clay, but has its own K_{sat} (see Table 17). Other material properties for this material are redirected to those of Unit 4 (see Table 8).

Table 17. Liner clay material properties

GoldSim element	value or distribution	units	reference / comment
Ksat_LinerClay	LN(GM=1e-6, GSD=1.2)	cm/s	see Unsaturated Zone Modeling white paper

4.13 \Materials\UO3_Waste_Properties

UO_3 waste is typical of the Savannah River Site DU waste stream. Note, however, that given that the DU-containing waste layer is overwhelmingly inert fill by volume, the material properties for this layer as modeled are set to those of Unit 3 (see Table 9).

4.14 \Materials\Waste_U3O8_Properties

U_3O_8 waste is typical of the gaseous diffusion plant DU waste streams. Like the UO_3 waste, the material properties for this layer as modeled are set to those of Unit 3 (see Table 9).

4.15 \Materials\Generic_Waste_Properties

The current Clive DU PA Model has no generic waste inventory, but this material is defined as a placeholder. Any layers to be filled with generic LLW borrow material properties from Unit 3 (see Table 9).

4.16 \Materials\Water_Properties

Water is the reference fluid in GoldSim.

Table 18. Properties of water, the reference fluid.

GoldSim element	value or distribution	units	reference / comment
RefDiffusivity_Water reference diffusivity in Water	1×10^{-9}	m^2/s	as given in the GoldSim manual
Dm molecular diffusivity in Water	U(3e-6, 2e-5)	cm^2/s	see the Geochemical Modeling white paper

4.17 \Materials\Kd

Since the K_d distribution for each element and each material can be defined independently, with a different distributional form, the Model Parameters workbook does not lend itself to listing these as a vector. Instead, each chemical element is listed in the following tables, one table for each material. Materials are limited to sand, silt, and clay, which spans the gross material properties found at the site. Since the depleted uranium is assumed to be dispersed in a large volume of fill material of as yet unspecified characteristics, the material properties of the disposed waste generally assumes the properties of this fill material. For now, then, the uranium oxide wastes are not assigned their own chemical properties.

4.17.1 \Materials\Kd\Kd_Sand_Values

Table 19. Soil/water partition coefficients (K_ds) for sand

chemical element	value or distribution	units	reference / comment
Ac	LU(min=16.8, max=535)	mL/g	see Geochemical Modeling white paper
Am	LU(min=43.2, max=811)	mL/g	*ibid.*
Cs	LU(min=2.70, max=22.2)	mL/g	*ibid.*
I_dist	N(0.428, 0.605), with values less than 0 set to 0.	mL/g	*ibid*.; Values sampled below 0 are set to 0, within the Expression I.

chemical element	value or distribution	units	reference / comment
Np	LU(min=0.392, max=51)	mL/g	*ibid.*
Pa	LU(min=8.32, max=331)	mL/g	*ibid.*
Pb	LU(min=2.70, max=22.2)	mL/g	*ibid.*
Pu	LU(min=66.9, max=2390)	mL/g	*ibid.*
Ra	LU(min=0.387, max=64.6)	mL/g	*ibid.*
Rn	0	mL/g	*ibid.*
Sr	LU(min=2.7, max=22.2)	mL/g	*ibid.*
Tc_dist	N(0.102, 0.145), with values less than 0 set to 0.	mL/g	*ibid*.; Values sampled below 0 are set to 0, within the Expression Tc.
Th	LU(min=19.2, max=41.6)	mL/g	*ibid.*
U	LU(min=0.344, max=6.77)	mL/g	*ibid.*

4.17.2 \Materials\Kd\Kd_Silt_Values

Table 20. Soil/water partition coefficients (K_ds) for silt

chemical element	value or distribution	units	reference / comment
Ac	LU(min=15.7, max=1910)	mL/g	see Geochemical Modeling white paper
Am	LU(min=88.0, max=1140)	mL/g	*ibid.*
Cs	LU(min=4.23, max=118)	mL/g	*ibid.*
I	Equal to Kd for I in Sand	mL/g	*ibid.*
Np	LU(min=0.805, max=62.1)	mL/g	*ibid.*
Pa	LU(min=184, max=978)	mL/g	*ibid.*
Pb	LU(min=4.23, max=118)	mL/g	*ibid.*
Pu	LU(min=80.5, max=6210)	mL/g	*ibid.*
Ra	LU(min=0.797, max=75.3)	mL/g	*ibid.*
Rn	0	mL/g	*ibid.*
Sr	LU(min=4.23, max=118)	mL/g	*ibid.*
Tc	Equal to Kd for Tc in Sand	mL/g	*ibid.*
Th	LU(min=34.4, max=697)	mL/g	*ibid.*
U	LU(min=0.880, max=11.4)	mL/g	*ibid.*

4.17.3 \Materials\Kd\Kd_Clay_Values

Table 21. Soil/water partition coefficients (K_ds) for clay

chemical element	value or distribution	units	reference / comment
Ac	LU(min=83.6, max=2990)	mL/g	see Geochemical Modeling white paper
Am	LU(min=88.0, max=1140)	mL/g	*ibid.*
Cs	LU(min=6.69, max=239)	mL/g	*ibid.*
I	Equal to Kd for I in Sand	mL/g	*ibid.*
Np	LU(min=4.32, max=81.1)	mL/g	*ibid.*
Pa	LU(min=180, max=1560)	mL/g	*ibid.*
Pb	LU(min=6.69, max=239)	mL/g	*ibid.*
Pu	LU(min=914, max=5470)	mL/g	*ibid.*
Ra	LU(min=1.42, max=1410)	mL/g	*ibid.*

chemical element	value or distribution	units	reference / comment
Rn	0	mL/g	*ibid.*
Sr	LU(min=6.69, max=239)	mL/g	*ibid.*
Tc	Equal to Kd for Tc in Sand	mL/g	*ibid.*
Th	LU(min=84.7, max=2360)	mL/g	*ibid.*
U	LU(min=9.05, max=66.3)	mL/g	*ibid.*

4.18 \Materials\WaterSolubility

Since the aqueous solubility distribution for each element and each material could be defined independently, with a different distributional form, the Model Parameters workbook does not lend itself to listing these as a vector. Instead, each chemical element is listed in the following table.

4.18.1 \Materials\WaterSolubility\Solubilities_Saltwater

Table 22. Aqueous solubilities in saltwater, by chemical element

chemical element	value or distribution	units	reference / comment
Ac	LU(min=6.81e-9, max=1.47e-5)	mol/L	see Geochemical Modeling white paper
Am	LU(min=6.81e-10, max=1.47e-6)	mol/L	*ibid.*
Cs	LU(min=6.81e-3, max=1.47e1)	mol/L	*ibid.*
I	LU(min=5.99e-5, max=1.67e0)	mol/L	*ibid.*
Np	LU(min=6.81e-6, max=1.47e-2)	mol/L	*ibid.*
Pa	LU(min=6.81e-9, max=1.47e-5)	mol/L	*ibid.*
Pb	LU(min=6.81e-9, max=1.47e-5)	mol/L	*ibid.*
Pu	LU(min=5.27e-11, max=1.90e-5)	mol/L	*ibid.*
Ra	LU(min=5.99e-10, max=1.67e-5)	mol/L	*ibid.*
Rn	LU(min=7.74e-4, max=1.29e-1)	mol/L	*ibid.*
Sr	LU(min=6.81e-7, max=1.47e-3)	mol/L	*ibid.*
Tc	LU(min=7.74e-5, max=1.29e-2)	mol/L	*ibid.*
Th	LU(min=7.74e-9, max=1.29e-6)	mol/L	*ibid.*
UO3	LU(min=3.58e-6, max=2.79e-3)	mol/L	*ibid.*
U3O8	LU(min=1e-16, max=6.5e-10)	mol/L	*ibid.*

4.19 \Materials\AirDiffusivities

Currently, the only gaseous radionuclide in the model is ^{222}Rn, which diffuses in the air phase.

Table 23. Parameters relevant to diffusion in air.

GoldSim element	value or distribution	units	reference / comment
RefDiffusivity_Air	1	cm^2/s	arbitrary value in GoldSim, as it falls out in math
Da_Rn	0.11	cm^2/s	Rogers and Nielson (1991)

4.20 \Materials\Kh

Radon also partitions into water according to its Henry's Law constant.

Table 24. Henry's Law constants and related parameters.

GoldSim element	value or distribution	units	reference / comment
SoilTemp average soil temperature	N(μ=12, σ=1)	°C	Estimated from the Clive Test Cell temperature data "Temp and Dose Data 9-19-01 to 1-15-09.xls" provided by Energy*Solutions.*
Khcp_Rn parameter used in devising Henry's Law constant	9.3e-3	mol/L·atm	Sander (1999), table 7, page 13

5.0 \Processes

Physical process parameters global in scope (general to the entire model) are defined in this container.

5.1 \Processes\AirTransport

Contaminant transport in air includes both pore air in porous media, and the dispersion into and within the atmosphere. Chi/Q values for gas and particles that are specific to the Class A South embankment are listed in Table 43(for the \Disposal\AtmosphericDispersion\AirConc_Remote container).

Table 25. Radon diffusive transport parameters.

GoldSim element	value or distribution	units	reference / comment
EPRatio_Radon radon escape/production ratio	beta(0.290, 0.156, min=0, max=1)	—	see Unsaturated Zone Modeling white paper
ThicknessAtm mixing thickness of the atmosphere, for purposes of diffusion from soil layers	N(μ=2.0, σ=0.5, min=Small, max=Large)	m	*ibid.*
WindSpeed average wind speed, for purposes of diffusion from soil layers	N(μ=3.14, σ=0.5, min=Small, max=Large)	m/s	*ibid.*
AtmDiffusionLength diffusion length for the atmosphere, for purposes of diffusion from soil layers	N(μ=0.1, σ=0.02, min=Small, max=Large)	m	*ibid.*

Table 26. Atmospheric transport parameters.

GoldSim element	value or distribution		units	reference / comment
Dust_mask logical mask to identify PM-10 particles	Rn = 0, all others = 1 (see workbook)		—	masks Species with 0/1 to be those found in dust particles
Gas_mask logical mask to identify gases	Rn = 1, all others = 0 (see workbook)		—	masks Species with 0/1 to be those found in gaseous phase
ResuspensionFlux mass flux of soil particles into atmosphere	LU(Small, 0.3)		kg/m^2-yr	see Atmospheric Modeling white paper
Particle_Fraction the fraction of PM-10 particles in the 0 to 2.5 μm size bin	U(0,1)		—	based on physical limits
Frac_OffSite_ Deposition fraction of all particles that migrate off site that are deposited in the off-	0	0.11	—	see Atmospheric Modeling white paper
	0.05	0.11	—	
	0.1	0.11	—	
	0.2	0.099	—	

GoldSim element	value or distribution		units	reference / comment
site air dispersion area. a lookup table based on Particle_Fraction	0.4	0.086	—	
	0.6	0.072	—	
	0.8	0.057	—	
	1.0	0.041	—	
OnSiteRedepos_ Ratio_bySize a lookup table based on Particle_Fraction	0	4.224e-7	g/m^2-yr per g/yr	*ibid.*
	0.05	4.114e-7		
	0.1	4.002e-7		
	0.2	3.776e-7		
	0.4	3.311e-7		
	0.6	2.827e-7		
	0.8	2.321e-7		
	1.0	1.794e-7		

5.2 \Processes\AnimalTransport

Burrowing animals have the potential to exhume waste or contaminated cap materials. All burrowers are collected into one of two types: ants and small mammals.

5.2.1 \Processes\AnimalTransport\AntData

Table 27. Model parameters for ants.

GoldSim element	value or distribution	units	reference / comment
NestVolume volume of each nest	N(μ=0.161, σ=0.024, min=0, max=Large)	m^3	see Biological Modeling white paper
ColonyLifespan lifespan of each colony	N(μ=20.2, σ=3.6, min=Small, max=Large)	yr	*ibid.*
ColonyDensity area density of colonies on the ground	see below for each field study plot	1/ha	*ibid.*
_Plot1	Gamma(33,1, min=0, max=Large)	1/ha	*ibid.*
_Plot2	Gamma(2, 1, min=0, max=Large)	1/ha	*ibid.*
_Plot3	Gamma(7, 1, min=0, max=Large)	1/ha	*ibid.*
_Plot4	Gamma(17, 1, min=0, max=Large)	1/ha	*ibid.*
_Plot5	Gamma(6, 1, min=0, max=Large)	1/ha	*ibid.*

GoldSim element	value or distribution	units	reference / comment
MaxDepth maximum depth for any colony	212	cm	*ibid.*
b fitting parameter for nest shape	N(μ=10, σ=0.71, min=1, max=Large)	—	*ibid.*

5.2.2 \Processes\AnimalTransport\MammalData

Table 28. Model parameters for small mammals.

GoldSim element	value or distribution	units	reference / comment
MoundDensity area density of mounds on the ground	see below for each plot	1/ha	see Biological Modeling white paper
_Plot1	Gamma(235, 1, min=0, max=Large)	1/ha	*ibid.*
_Plot2	Gamma(239, 1, min=0, max=Large)	1/ha	*ibid.*
_Plot3	Gamma(1.33, 1, min=0, max=Large)	1/ha	*ibid.*
_Plot4	Gamma(1.33, 1, min=0, max=Large)	1/ha	*ibid.*
_Plot5	Gamma (1.33, 1, min=0, max=Large)	1/ha	*ibid.*
ExcavationRate volumetric rate of a single burrow excavation	N(μ=0.0006, σ=0.00015, min=Small, max=Large)	m^3/yr	*ibid.*
MaxDepth maximum depth for any burrow	200	cm	*ibid.*
b fitting parameter for burrow shape	N(μ=4.5, σ=0.84, min=1, max=Large)	—	*ibid.*

5.3 \Processes\PlantTransport

Plants have the potential to translocate contaminants in waste or contaminated cap materials. All plants are collected into one of five types: greasewood, grasses, forbs, trees, and shrubs. Each of these plant types is characterized in each of the five plot locations that were studied, corresponding to five vegetation associations:

- Plot 1: Mixed Grassland
- Plot 2: Juniper - Sagebrush
- Plot 3: Black Greasewood
- Plot 4: Halogeton - Disturbed
- Plot 5: Shadscale - Gray Molly

Each of these vegetation associations is picked at random for a given realization.

Table 29. Parameters general to all plants.

GoldSim element	value or distribution	units	reference / comment
BiomassProductionRate	U(300, 1500)	kg/ha-yr	see *Biological Modeling* white paper
VegetationAssociationPicker	discrete(1, 2, 3, 4, 5)	—	*ibid.*

5.3.1 \Processes\PlantTransport\PlantCR

Table 30. Plant/soil concentration ratio parameters.

GoldSim element	value or distribution	units	reference / comment
CR_GM	tabulated in Clive PA Model Parameters.xls workbook	—	see *Biological Modeling* white paper
CR_GSD	tabulated in Clive PA Model Parameters.xls workbook	—	*ibid.*
CR_GM_radon	Small	—	*ibid.*
CR_GSD_radon	1	—	*ibid.*

5.3.2 \Processes\PlantTransport\BiomassCalcs

Table 31. Biomass calculation parameters.

GoldSim element	value or distribution	units	reference / comment

GoldSim element	value or distribution	units	reference / comment
percent cover tables, such as PctCover_Plot4_Forb	tabulated in Clive PA Model Parameters.xls workbook	%	These are 25 tables, one for each Plot and for each plant type. Source: plant.cover.percent.simulations.xlsx in Clive PA Model Parameters.xls workbook
PctCoverRandomSelector	probability of 0.001 assigned to discrete values from 1 to 1000	%	An index generator used to pick correlated sets of percent cover

5.3.3 \Processes\PlantTransport\GreasewoodData

Table 32. Greasewood parameters.

GoldSim element	value or distribution	units	reference / comment
RootShoot_Ratio	U(0.30, 1.24)	—	see Biological Modeling white paper
MaxDepth	570	cm	*ibid.*
b	N(μ=14.6, σ=0.0807, min=1, max=Large)	—	*ibid.*

5.3.4 \Processes\PlantTransport\GrassData

Table 33. Grass parameters.

GoldSim element	value or distribution	units	reference / comment
RootShoot_Ratio	T(1, 1.2, 2)	—	see Biological Modeling white paper
MaxDepth	150	cm	*ibid.*
b	N(μ=2.19 σ=0.036, min=1, max=Large)	—	*ibid.*

5.3.5 \Processes\PlantTransport\ForbData

Table 34. Forb parameters.

GoldSim element	value or distribution	units	reference / comment
RootShoot_Ratio	U(0.40, 1.80)	—	see Biological Modeling white paper
MaxDepth	51	cm	*ibid.*

GoldSim element	value or distribution	units	reference / comment
b	N(μ=23.9 σ=0.313, min=1, max=Large)	—	*ibid.*

5.3.6 \Processes\PlantTransport\TreeData

Table 35. Tree parameters.

GoldSim element	value or distribution	units	reference / comment
RootShoot_Ratio	U(0.55, 0.76)	—	see Biological Modeling white paper
MaxDepth	450	cm	*ibid.*
b	N(μ=14.6 σ=0.0807, min=1, max=Large)	—	*ibid.*

5.3.7 \Processes\PlantTransport\ShrubData

Table 36. Other shrub parameters.

GoldSim element	value or distribution	units	reference / comment
RootShoot_Ratio	U(0.4, 1.8)	—	see Biological Modeling white paper
MaxDepth	110	cm	*ibid.*
b	N(μ=23.9 σ=0.313, min=1, max=Large)	—	*ibid.*

5.4 \Processes\WaterTransport

Flow within moving water (advection) and diffusion within water are typically significant contaminant transport mechanisms. Global parameters for water transport are located here. Other parameters specific to a modeled column are located within that column's modeling container (e.g. Section Table 46) or that material property's modeling container (e.g Section 4.10, Table 15).

Table 37. Water transport parameters.

GoldSim element	value or distribution	units	reference / comment
Water tortuosity water content exponent	N(μ=7/3, σ=0.01)	—	*Ibid.*
Water tortuosity porosity exponent	N(μ=2.0, σ=0.01	—	*Ibid.*

5.5 \Processes\ErosionTransport

Erosion through the formation of gullies can be a significant mechanism for exposing waste to the environment. Global parameters for erosion are located here. Other parameters specific to an embankment are located within that embankment's modeling container (e.g. Section

\Disposal\ClassASouthCell\ErosionCalcs\SiberiaErosionCalcs

SIBERIA modeling results were used to create 1000 realization inputs for gully density for each modeling cell layer.

Table 61. SIBERIA erosion parameters.

GoldSim element	value or distribution	units	reference / comment
FractionGully	Lookup table with 1000 realizations	—	See Erosion Modeling white paper.
GullyRandomSelector	discrete(1, ..., 1000) equal probability (0.001)		*ibid.*

5.5.1.1 \Disposal\ClassASouthCell\ErosionCalcs\GullyAndFanV1

Table 62). These parameters are for the initial gully screening calculations from Model v.1.0. Those screening calculations are still in the model, although they are not used in the dose assessment.

Table 38. Water transport parameters.

GoldSim element	value or distribution	units	reference / comment
AngleOfRepose_Gully angle of repose for gully walls	N(μ=38, σ=5, min=Small, max=90-Small)	degrees	see Erosion Modeling white paper
Gully_b_parameter shape parameter for gully thalweg	N(μ=-0.4, σ=0.15, min=-0.75, max=-0.05)	—	*ibid.*

6.0 \Inventory

The DU waste is characterized by analysis of the SRS DU. To date, insufficient information exists to thoroughly characterize the DU wastes expected to arrive from the gaseous diffusion plants (GDPs).

6.1 \Inventory\SRS_DU_Inventory

The SRS DU, which consists of several thousand 208-L (55-gal) drums of powdered DUO_3, has been subjected to laboratory analysis, so activity concentrations are based on that information.

Table 39. SRS DU inventory parameters.

GoldSim element	value or distribution	units	reference / comment
ActivityConc_DUWaste_Mean	See parameters workbook, sheet “Inventory”	pCi/g	see Waste Inventory white paper
ActivityConc_DUWaste_StdDev	See parameters workbook, sheet “Inventory”	pCi/g	see Waste Inventory white paper
SRS_DU_Drums_Disposed	21000	—	(not considered in this PA)
SRS_DU_Drums_ProposedUT	5408	—	see Waste Inventory white paper
SRS_DU_Drums_ProposedEW	5408 × 2	—	(not considered in this PA)
Drum_Mass	20	kg	see Waste Inventory white paper
ShippedMass_Proposed_UT	3577	Mg	see Waste Inventory white paper

6.2 \Inventory\GDP_DU_Inventory

Since insufficient information exists to exactly characterize the DU wastes expected to arrive from the GDPs, the activity concentrations and other waste material characteristics are borrowed from the SRS DUO_3 waste, as a proxy.

Table 40. GDP DU inventory parameters.

GoldSim element	value or distribution	units	reference / comment
Num_DUF6_Cylinders_PGDP	36191	—	see Waste Inventory white paper
Num_DUF6_Cylinders_PORTS	16109	—	*ibid.*
Num_DUF6_Cylinders_K25	4822	—	*ibid.*
Mass_DUF6_PGDP	436400	Mg	*ibid.*
Mass_DUF6_PORTS	195800	Mg	*ibid.*
Mass_DUF6_K25	54300	Mg	*ibid.*
CylinderDiameter	4	ft	*ibid.*
CylinderLength	12	ft	*ibid.*

GoldSim element	value or distribution	units	reference / comment
FractionGDP_Contaminated	Beta(0.0392, 0.0025, 0, 1)	—	*ibid.*
CleanDU_Mask	see workbook	—	simply a mask for uranium

6.3 \Inventory\Other_DU_Inventory

This is a placeholder container. No other DU inventory is assumed in the model.

6.4 \Inventory\ClassA_LLW_Inventory

This is a placeholder container. No other LLW inventory is assumed in the model.

7.0 \Disposal

The Disposal container hosts all the actual contaminant calculations, including atmospheric transport, transport mechanisms within each column of each embankment (water, air, biological, etc.) and the saturated zone. While global transport parameters are defined in the \Processes container (Section), parameters and calculations specific to local mechanisms are defined here.

7.1 \Disposal\AtmosphericDispersion

The values for the ratio of airborne contaminant concentration to source release rate into the atmosphere are known as X/Q (Chi/Q) values. These are implemented as lookup tables on Particle_Fraction.

7.1.1 \Disposal\AtmosphericDispersion\AirConc_Onsite

OnSite air concentrations are used for exposures to receptors that traverse the embankment itself.

Table 41. Atmosphere dispersion parameters for on-site exposures.

GoldSim element	value or distribution		units	reference / comment
ChiQ_Embankment_538m	0	222	(µg/m^3)/(g/s)	see Atmospheric Modeling white paper
	0.05	223		
	0.1	224		
	0.2	225		
	0.4	228		
	0.6	231		
	0.8	234		

GoldSim element	value or distribution		units	reference / comment
	1.0	238		
ChiQ_Gas_Onsite (Embankment)	234		same	*ibid.*

7.1.2 \Disposal\AtmosphericDispersion\MediaConc_Offsite

OffSite air concentrations are used for exposures to receptors that traverse the area surrounding the embankment. These receptors also have access to the embankment itself. Functionally, the air concentrations are set to those same values used for OnSite air.

Table 42. Atmosphere dispersion parameters for off-site exposures (in the "air dispersion" area.)

GoldSim element	value or distribution	units	reference / comment
ChiQ_Dust_Offsite	set equal to ChiQ_Dust _Onsite	(µg/m^3)/(g/s)	see Atmospheric Modeling white paper
ChiQ_Gas_Offsite	0.38	same	*ibid.*

7.1.3 \Disposal\AtmosphericDispersion\AirConc_Remote

Various receptors are at specific geographic locations farther away from the site, including Interstate-80, the rail road, the Grassy Rest Area, the Knolls OHV Recreation Area, and the UTTR access road.

Table 43. Atmosphere dispersion parameters for remote off-site exposures.

GoldSim element	value or distribution		units	reference / comment
ChiQ_RestArea_1K	0	0.0069	(µg/m^3)/(g/s)	see Atmospheric Modeling white paper
	0.05	0.0069		
	0.1	0.0069		
	0.2	0.0070		
	0.4	0.0071		
	0.6	0.0072		
	0.8	0.0073		
	1.0	0.0074		

GoldSim element	value or distribution		units	reference / comment
ChiQ_Gas_RestArea	0.0088		same	*ibid.*
ChiQ_Knolls	0	0.043	same	*ibid.*
	0.05	0.044		
	0.1	0.044		
	0.2	0.046		
	0.4	0.049		
	0.6	0.052		
	0.8	0.055		
	1.0	0.058		
ChiQ_Gas_Knolls	0.053		same	*ibid.*
ChiQ_I80_1K	0	0.26	same	*ibid.*
	0.05	0.26		
	0.1	0.26		
	0.2	0.27		
	0.4	0.27		
	0.6	0.28		
	0.8	0.28		
	1.0	0.28		
ChiQ_Gas_I80	0.28		same	*ibid.*
ChiQ_Railroad_1K	0	0.43	same	*ibid.*
	0.05	0.43		
	0.1	0.43		
	0.2	0.43		
	0.4	0.43		
	0.6	0.44		
	0.8	0.44		
	1.0	0.44		
ChiQ_Gas_Railroad	0.44		same	*ibid.*
ChiQ_UTTRaccess_1K	0	222	same	*ibid.*
	0.05	223		
	0.1	224		

GoldSim element	value or distribution		units	reference / comment
	0.2	225		
	0.4	228		
	0.6	231		
	0.8	234		
	1.0	238		
ChiQ_Gas_UTTRaccess	234		same	*ibid.*

7.2 \Disposal\ClassASouthCell

This PA model considers only the Class A South cell, part of the Federal Cell embankment.

7.2.1 \Disposal\ClassASouthCell\ClassASouth_Cell_Dimensions

Exact dimensions of the embankment are somewhat irregular, so the shape of the cell has been somewhat idealized to facilitate calculations. Elevations for the top of the waste are read from drawing 07021 V1, which has the note “1. All elevations shown are for top of waste...” Elevation of bottom of waste is from drawing 07021 V3.

Table 44. Interior (waste) dimensions of the Federal Cell, Class A South section.

GoldSim element	value or distribution	units	reference / comment
OriginalGrade Average original grade elevation	4272	ft amsl	see Embankment Modeling.pdf
WasteTopElev_Ridge Elevation of top of the waste at the ridgeline	4317.25	ft amsl	*ibid.*
AverageWasteTopElev_Break Elevation of top of the waste at the break in slope	4299.20	ft amsl	*ibid.*
WasteBottomElev Elevation of the bottom of the waste	4264.17	ft amsl	*ibid.*
LengthOverall Length overall	1429.6	ft	*ibid.*
WidthOverall Width overall	1775	ft	*ibid.*

GoldSim element	value or distribution	units	reference / comment
LengthToBreak Length from edge to the break in slope	153.2	ft	*ibid.*
WidthToBreak Width from edge to the break in slope	152.1	ft	*ibid.*
RidgeLength Length along the ridge	542.1	ft	*ibid.*

7.2.2 \Disposal\ClassASouth\NaturalSystemGeometry

Table 45. Natural system geometry parameters for the Class A South cell.

GoldSim element	value or distribution	units	reference / comment
UZ_Thickness thickness of the unsaturated zone below the CAS cell	N(μ=12.9, σ=0.25, min=Small, max=Large)	ft	see Unsaturated Zone Modeling white paper

7.2.3 \Disposal\ClassASouthCell\TopSlope

No input elements are defined at this level.

7.2.3.1 \Disposal\ClassASouthCell\TopSlope\Column_Transport

No input elements are defined at this level.

7.2.3.1.1 \Disposal\ClassASouthCell\TopSlope\Column_Transport \WaterTransport

Water flow calculations for the top slope column are performed here. These parameters are clones for the side slope.

Table 46. Infiltration parameters for cap cells.

GoldSim element	value or distribution	units	reference / comment
B_0 Regression parameter	0.959	—	see Unsaturated Zone Modeling white paper, units of mm/yr are added after the regression is calculated

GoldSim element	value or distribution	units	reference / comment
B_2 Regression parameter	4.4	—	*ibid.*
B_3 Regression parameter	-0.521	—	*ibid.*

7.2.3.2 \Disposal\ClassASouthCell\TopSlope\Column_MoistureProfile

7.2.3.2.1 \Disposal\ClassASouthCell\TopSlope\Column_MoistureProfile\WaterContentCalcs_ETCover

These elements are cloned in the corresponding side slope container.

Table 47. Parameters for moisture profile calculations for the ET Cover.

GoldSim element	value		units	reference / comment
B_0 Regression parameter vector	SurfaceSoil EvapLayer FrostLayer UpperRnBarrier LowerRnBarrier	0.554 0.684 0.0726 0.3 0.3		see Unsaturated Zone Modeling white paper
B_1 Regression parameter vector	SurfaceSoil EvapLayer FrostLayer UpperRnBarrier LowerRnBarrier	-0.00197 -0.00222 0.000169 -0.00361 -0.00361	day/cm	*Ibid.*
B_2 Regression parameter vector	SurfaceSoil EvapLayer FrostLayer UpperRnBarrier LowerRnBarrier	-0.0555 -0.157 0.0521 0.314 0.314		*Ibid.*
B_3 Regression parameter vector	SurfaceSoil EvapLayer FrostLayer UpperRnBarrier LowerRnBarrier	-0.222 -0.288 -7.27E-06 -0.013 -0.013		*Ibid.*

GoldSim element	value		units	reference / comment
WaterContentResidual	SurfaceSoil	0.11		*Ibid.*
	EvapLayer	0.11		
	FrostLayer	0.065		
	UpperRnBarrier	0.1		
	LowerRnBarrier	0.1		

7.2.3.2.2 \Disposal\ClassASouthCell\TopSlope\Column_MoistureProfile \WaterContentCalcs_RnBarrier

These calculations are no longer used in the model. They are currently present for reference only.

Table 48. Parameters for moisture profile calculations for the radon barrier.

GoldSim element	value	units	reference / comment
NumNodes	5		this is the number of modeled radon barrier layers +1
UpperRn_NodeNumber	2		middle node in part of column
LowerRn_NodeNumber	4		middle node in part of column

7.2.3.2.3 \Disposal\ClassASouthCell\TopSlope\Column_MoistureProfile \WaterContentCalcs_Waste

Table 49. Parameters for moisture profile calculations for the waste.

GoldSim element	value	units	reference / comment
NumNodes	28	—	this is the number of modeled waste layers +1

7.2.3.2.4 \Disposal\ClassASouthCell\TopSlope\Column_MoistureProfile \WaterContentCalcs_Liner

Table 50. Parameters for moisture profile calculations for the clay liner.

GoldSim element	value	units	reference / comment
NumNodes	5		this is the number of modeled liner layers +1
MiddepthNodeNumber	3		middle node in column

7.2.3.2.5 \Disposal\ClassASouthCell\TopSlope\Column_MoistureProfile \WaterContentCalcs_Unsat

Table 51. Parameters for moisture profile calculations for the unsaturated zone below the clay liner.

GoldSim element	value or distribution	units	reference / comment
NumNodes	24		see Unsaturated Zone Modeling white paper
ZoneThickness specified from the bottom up	-0.0204 -0.0204 -0.0204 -0.0204 -0.0204 -0.0510 -0.0510 -0.0510 -0.2550 -0.2550 -0.2550 -0.2550 -0.2550 -0.2550 -0.2550 -0.2550 -0.2550 -0.2550 -0.2550 -0.2550 -0.2550 -0.2550 -0.2550 0	m	*ibid.*
MiddepthNodeNumber	16		middle node in column

7.2.3.3 \Disposal\ClassASouthCell\TopSlope\Cap_Layers

7.2.3.3.1 \Disposal\ClassASouthCell\TopSlope\CapLayers\CapCell_Dimensions

Table 52. Cap layering dimensions for the top slope.

GoldSim element	value or distribution	units	reference / comment
TArmor Type B rip rap thickness	18	in	see Embankment Modeling white paper

GoldSim element	value or distribution	units	reference / comment
TUpperFilter Type A filter zone thickness	6	in	*ibid.*
TSacrificialSoil Sacrificial soil thickness	12	in	*ibid.*
TLowerFilter Type B filter zone thickness	6	in	*ibid.*
TUpperRadon upper radon barrier clay thickness	12	in	*ibid.*
TLowerRadon lower radon barrier clay thickness	12	in	*ibid.*
NArmorCells	3	—	modeling construct
NUpperFilterCells	1	—	modeling construct
NSacrificialSoilCells	2	—	modeling construct
NLowerFilterCells	1	—	modeling construct
NUpperRadonCells	2	—	modeling construct
NLowerRadonCells	2	—	modeling construct
TopCell_Thickness	U(1 cm, TArmor – NArmorCells × 1 cm)	cm	modeling construct This allows the thickness of the topmost cell to vary between 1 cm and the maximum so that the other cells in this layer are at least 1 cm.

7.2.3.4 \Disposal\ClassASouthCell\TopSlope\Liner

Table 53. Number of liner cells.

GoldSim element	value or distribution	units	reference / comment
NumLinerCells	4	—	modeling construct

7.2.3.5 \Disposal\ClassASouthCell\TopSlope\UnsatLayer

Table 54. Number of unsaturated zone cells.

GoldSim element	value or distribution	units	reference / comment
NumUnsatCells	10	—	modeling construct

7.2.3.6 \Disposal\ClassASouthCell\TopSlope\WasteLayers

No input elements are defined at this level.

7.2.3.6.1 \Disposal\ClassASouthCell\TopSlope\WasteLayers\WasteCell_Dimensions

Table 55. Top slope waste cell dimensions.

GoldSim element	value or distribution	units	reference / comment
NumWasteCells_TS	27	—	modeling construct

7.2.4 \Disposal\ClassASouthCell\SideSlope

No input elements are defined at this level.

7.2.4.1 \Disposal\ClassASouthCell\SideSlope\Column_Transport

No input elements are defined at this level.

7.2.4.1.1 \Disposal\ClassASouthCell\SideSlope\Column_Transport\WaterTransport

No input elements are defined at this level.

7.2.4.2 \Disposal\ClassASouthCell\SideSlope\Column_MoistureProfile

7.2.4.2.1 \Disposal\ClassASouthCell\SideSlope\Column_MoistureProfile\WaterContentCalcs_RnBarrier

Table 56. Parameters for moisture profile calculations for the radon barrier.

GoldSim element	value	units	reference / comment
NumNodes	5		this is the number of modeled radon barrier layers +1

GoldSim element	value	units	reference / comment
UpperRn_NodeNumber	2		middle node in part of column
LowerRn_NodeNumber	4		middle node in part of column

7.2.4.2.2 \Disposal\ClassASouthCell\SideSlope\Column_MoistureProfile \WaterContentCalcs_Waste

Table 57. Parameters for moisture profile calculations for the waste.

GoldSim element	value	units	reference / comment
NumNodes	13	—	this is the number of modeled waste layers +1

7.2.4.2.3 \Disposal\ClassASouthCell\SideSlope\Column_MoistureProfile \WaterContentCalcs_Liner

Table 58. Parameters for moisture profile calculations for the clay liner.

GoldSim element	value	units	reference / comment
NumNodes	5		this is the number of modeled liner layers +1
MiddepthNodeNumber	3		middle node in column

7.2.4.2.4 **\Disposal\ClassASouthCell\SideSlope\Column_MoistureProfile \WaterContentCalcs_Unsat**

Parameters for moisture profile calculations for the unsaturated zone below the clay liner in the side slope are identical to those for the top slope, as listed in Table 51.

7.2.4.3 \Disposal\ClassASouthCell\SideSlope\Cap_Layers

7.2.4.3.1 \Disposal\ClassASouthCell\SideSlope\CapLayers\CapCell_Dimensions

Table 59. Cap layering dimensions for the side slope.

GoldSim element	value or distribution	units	reference / comment
TArmor Type A rip rap thickness	18	in	see Embankment Modeling white paper
TUpperFilter Type A filter zone thickness	6	in	*ibid.*
TSacrificialSoil Sacrificial soil thickness	12	in	*ibid.*

GoldSim element	value or distribution	units	reference / comment
TLowerFilter Type B filter zone thickness	18	in	*ibid.* (Note how this is different from the TopSlope value.)
TUpperRadon upper radon barrier clay thickness	12	in	*ibid.*
TLowerRadon lower radon barrier clay thickness	12	in	*ibid.*
NArmorCells	3	—	modeling construct
NUpperFilterCells	1	—	modeling construct
NSacrificialSoilCells	2	—	modeling construct
NLowerFilterCells	1	—	modeling construct
NUpperRadonCells	2	—	modeling construct
NLowerRadonCells	2	—	modeling construct
TopCell_Thickness	U(1 cm, TArmor – NArmorCells × 1 cm)	cm	modeling construct This allows the thickness of the topmost cell to vary between 1 cm and the maximum so that the other cells in this layer are at least 1 cm.

7.2.4.4 \Disposal\ClassASouthCell\SideSlope\Liner

Parameters in this section are identical to those defined for the Top Slope in Section .

7.2.4.5 \Disposal\ClassASouthCell\SideSlope\UnsatLayer

Parameters in this section are identical to those defined for the Top Slope in Section .

7.2.4.6 \Disposal\ClassASouthCell\SideSlope\WasteLayers

No input elements are defined at this level.

7.2.4.6.1 \Disposal\ClassASouthCell\SideSlope\WasteLayers\WasteCell_Dimensions

Table 60. Side slope waste cell dimensions.

GoldSim element	value or distribution	units	reference / comment
NumWasteCells	12	—	modeling construct

7.2.5 \Disposal\ClassASouthCell\ErosionCalcs

The calculation of the volume, depth, and potential to expose waste by gullies is examined here. This work includes the preliminary calculations, designed to evaluate whether more sophisticated landform evolution modeling is warranted, as well as the more sophisticated erosion modeling using SIBERIA, a landscape evolution model.

7.2.5.1 \Disposal\ClassASouthCell\ErosionCalcs\SiberiaErosionCalcs

SIBERIA modeling results were used to create 1000 realization inputs for gully density for each modeling cell layer.

Table 61. SIBERIA erosion parameters.

GoldSim element	value or distribution	units	reference / comment
FractionGully	Lookup table with 1000 realizations	—	See Erosion Modeling white paper.
GullyRandomSelector	discrete(1, ..., 1000) equal probability (0.001)		*ibid.*

7.2.5.2 \Disposal\ClassASouthCell\ErosionCalcs\GullyAndFanV1

Table 62. Basic gully and fan definition parameters.

GoldSim element	value or distribution	units	reference / comment
NumberOfGullies	discrete(1, ..., 20) equal probability (0.05)	—	See Erosion Modeling white paper.
AngleOfRepose_Fan	U(5, 10)	deg	*ibid.*

7.2.5.3 \Disposal\ClassASouthCell\ErosionCalcs\GullyAndFanV1\GullyVolumeCalcs

The numerical (iterative) solution for gully and fan formation is done here.

Table 63. Gully and fan numerical solution parameters.

GoldSim element	value or distribution	units	reference / comment
ConvergenceCriterion	0.01	m^3	modeling construct

7.2.5.3.1 \Disposal\ClassASouthCell\ErosionCalcs\GullyAndFanV1\GullyVolumeCalcs\Dimensions

More numerical solution work for gully and fan formation is done here.

Table 64. More gully and fan numerical solution parameters.

GoldSim element	value or distribution	units	reference / comment
L_init	U(Small, 5)	m	see Erosion Modeling white paper
L	100	M	arbitrarily chosen for demonstration

7.3 \Disposal\SatZone

The saturated zone underlies and accepts recharge from all the embankments at the Clive Facility. All contaminated recharge flows down-gradient to a monitoring well.

7.3.1 \Disposal\SatZone\SatZone_Parameters

Table 65. Saturated zone parameters.

GoldSim element	value or distribution	units	reference / comment
SZ_Thickness	N(μ=16.2, σ=0.25, min=0.1, max=Large)	ft	see Saturated Zone Modeling white paper
MonitoringWellDistance	90	ft	*ibid.*
WaterTableGradient	N(μ=6.94e-4, σ=1.27e-4, min=0, max=Large)	—	*ibid.*

7.3.2 \Disposal\SatZone\SZ_ClassASouthFootprint

Table 66. Total number of cells in the saturated footprint zone.

GoldSim element	value or distribution	units	reference / comment
NumCells_Footprint	25		modeling construct

7.3.2.1 \Disposal\SatZone\SZ_ClassASouthFootprint\Waste_to_Footprint

Table 67. Total number of cells in both footprint ends.

GoldSim element	value or distribution	units	reference / comment
NumCells_Footprint_Ends	4		modeling construct

7.3.3 \Disposal\SatZone\SZ_ToWell

Table 68. Total number of cells from footprint to well.

GoldSim element	value or distribution	units	reference / comment
NumCells_ToWell	20		modeling construct

7.4 \Disposal\EngineeredSystemGeometry

Table 69. Engineered system geometry parameters.

GoldSim element	value	units	reference / comment
ClayLiner_Thickness	2	ft	see Embankment Modeling white paper

8.0 \Exposure_Dose

The Data element Dose_Timestep_Length is controlled by the user, and so has no set value.

8.1 \Exposure_Dose\Media_Concs

Concentrations of contaminants in environmental media to which receptors may be exposed are collected and calculated in this container.

Table 70. Mechanically generated dust

GoldSim element	value or distribution	units	reference / comment
OHV_DustAdjustment OHV dust loading	LN(GM=98.1, GSD=1.65, min=Small, max=Large)	—	See Dose Assessment white paper

8.1.1 \Exposure_Dose\Media_Concs\Exposure_Areas

Table 71. Exposure areas used in the calculation of exposure media concentrations

GoldSim element	value or distribution	units	reference / comment
Receptor_Area Receptor area (exposure area)	U(16,000, 64,000)	acres	See Dose Assessment white paper

GoldSim element	value or distribution	units	reference / comment
AntelopeRange_Area Pronghorn range area	U(995, 9192)	acres	*ibid.*

8.1.2 \Exposure_Dose\Media_Concs\Animal_Concentrations

Table 72. Animal tissue concentrations for the recreational and ranching scenarios

GoldSim element	value or distribution	units	reference / comment
TF_Beef_GM Beef transfer factor, geometric mean	Tabulated in workbook	day/kg	"Clive PA Model Parameters.xls", Elements worksheet; see also Dose Assessment white paper
TF_Beef_GSD Beef transfer factor, geometric standard deviation	Tabulated in workbook	—	*ibid.*
WaterIngRate_Cattle Cattle water ingestion rate	U(33, 53)	kg/day	See Dose Assessment white paper
ForageIngRate_Cattle Cattle forage ingestion rate	U(8.85, 14.75)	kg/day	*ibid.*
SoilIngRate_Cattle Cattle soil ingestion rate	U(0.05, 0.95)	kg/day	*ibid.*
GrazingTimeFrac_Cattle Cattle time fraction in exposure area	1	—	*ibid.*
WaterIngRate_Antelope Pronghorn water ingestion rate	U(0.1, 1)	kg/day	*ibid.*
BodyWtFactor_Antelope Pronghorn body weight, as a unitless factor for allometric scaling	U (38,000, 41,000)	—	*ibid.* Body mass in Dose Assessment white paper reported in units of kg.
ForageIngRate_Antelope Pronghorn forage ingestion rate	$0.577 \times$ BodyWtFactor _Antelope$^{0.727} \times 0.001$	kg/day	*ibid.*
SoilIngRate_Antelope Pronghorn soil ingestion rate	U(0.005, 0.095)	kg/day	*ibid.*

8.1.2.1 \Exposure_Dose\Media_Concs\Animal_Concentrations\Beef_TFs

The beef transfer factors are tabulated in the Parameters Workbook, but some values in those table point to fixed values in the GoldSim model. These are tabulated here:

Table 73. Parameters related to beef transfer factors

GoldSim element	value or distribution	units	reference / comment
BeefTF_GM_radon Beef transfer factor for radon, geometric mean	Small	day/kg	See Dose Assessment white paper
BeefTF_GSD_radon Beef transfer factor for radon, geometric standard deviation	1	—	*ibid.*
BeefTF_GSD_generic Generic beef transfer factor, geometric standard deviation	1.475	—	*ibid.*

8.2 \Exposure_Dose\DCFs

Table 74. Dose conversion factors

GoldSim element	value or distribution	units	reference / comment
BranchingFractions Radionuclide branching fractions	Tabulated in workbook	—	"Dose Assessment Appendix II.xls", see also Dose Assessment white paper
DCF_Inh_Dust_determ Dose conversion factor, inhalation dust	Tabulated in workbook	Sv/Bq	*ibid.*
DCF_Inh_Gas_determ Dose conversion factor, inhalation gas	Tabulated in workbook	Sv/Bq	*ibid.*
DCF_Ing_determ Dose conversion factor, ingestion	Tabulated in workbook	Sv/Bq	*ibid.*
DCF_Ext_Imm_determ Dose conversion factor, immersion	Tabulated in workbook	($Sv\text{-}m^3$)/(Bq-s)	*ibid.*
DCF_Ext_Soil_determ Dose conversion factor, external	Tabulated in workbook	($Sv\text{-}m^3$)/(Bq-s)	*ibid.*

GoldSim element	value or distribution	units	reference / comment
Rn222_EffectiveDose Effective dose for Radon-222	6	(mSv-m^3)/ (mJ-hr)	See Dose Assessment white paper
Rn_progeny_equil energy per Bq of radon at equilibrium	5.56E-06	mJ/Bq	*ibid.*
Rn_Inh_rate Breathing rate for a standard worker	1.2	m^3/hr	*ibid.*

8.2.1 \Exposure_Dose\DCFs\Stochastic_REFs

Table 75. Stochastic radiation effectiveness factors

GoldSim element	value or distribution	units	reference / comment
Alpha_GM Alpha radiation effectiveness factor, geometric mean	18.1	—	"Dose Assessment Appendix II.xls", see also Dose Assessment white paper
Alpha_GSD Alpha radiation effectiveness factor, geometric standard deviation	2.37	—	*ibid.*
Alpha_REF Alpha radiation effectiveness factor, distribution	LN(GM=Alpha_GM, GSD=Alpha_GSD)	—	*ibid.*
Beta_GM Electron radiation effectiveness factor, geometric mean	2.41	—	*ibid.*
Beta_GSD Electron radiation effectiveness factor, geometric standard deviation	1.44	—	*ibid.*
Beta_REF Electron radiation effectiveness factor, distribution	LN(GM=Beta_GM, GSD= Beta_GSD)	—	*ibid.*

GoldSim element	value or distribution	units	reference / comment
Photon1_GM Photon radiation effectiveness factor (30-250 keV), geometric mean	1.96	—	*ibid*. (>0.03 and <=0.25 MeV)
Photon1_GSD Photon radiation effectiveness factor (30-250 keV), geometric standard deviation	1.48	—	*ibid.*
Photon1_REF Photon radiation effectiveness factor (30-250 keV), distribution	LN(GM=Photon1_GM, GSD= Photon1_GSD)	—	*ibid.*
Photon2_GM Photon radiation effectiveness factor (< 30 keV), geometric mean	2.45	—	*ibid.*
Photon2_GSD Photon radiation effectiveness factor (< 30 keV), geometric standard deviation	1.55	—	*ibid.* (<=0.03 MeV)
Photon2_REF Photon radiation effectiveness factor (< 30 keV), distribution	LN(GM=Photon2_GM, GSD=Photon2_GSD)	—	*ibid.*
Deterministic_REF Deterministic radiation effectiveness factor	1	—	See Dose Assessment white paper
WeightingFactor_Alpha Weighting factor for alpha radiation	20	—	*ibid.*
WeightingFactor_Beta Weighting factor for beta radiation	1	—	*ibid.*
WeightingFactor_Gamma Weighting factor for gamma radiation	1	—	*ibid.*

8.3 \Exposure_Dose\OuterLoop_Exposure_Parameters

Table 76. Exposure parameters, sampled once per realization

GoldSim element	value or distribution		units	reference / comment
SoilIngestionTracerElement Adult incidental soil ingestion rate tracer elements	*Probability*	*Value*	—	See Dose Assessment white paper
	0.3333	0		Tracer element: silicon
	0.3334	1		Tracer element: aluminum
	0.3333	2		Tracer element: titanium
EF_food Exposure frequency, food	365		day/yr	See Dose Assessment white paper
Meat_PrepLoss Meat preparation loss	N(μ=0.27, σ=0.07, min = 0.01, max = 1)		—	*ibid.*
Meat_PostCookLoss Meat post-cooking loss	N(μ=0.24, σ=0.09, min = 0.01, max = 1)		—	*ibid.*

8.4 \Exposure_Dose\Dose_Calculations

This looping container performs calculations on a finer time step than the outer model, and has parameters that are sampled on the inner time steps.

8.4.1 \Exposure_Dose\Dose_Calculations\Physiology_Rancher

Table 77. Attributes of inter-individual uncertainty in physiological characteristics for rancher receptors (ranch hands)

GoldSim element	value or distribution	units	reference / comment
Age	N(μ=25.7, σ=20.3, min = 16, max = 60)	yr	See Dose Assessment white paper
Gender	Male 60.8%, Female 39.2%	—	*ibid.*

GoldSim element	value or distribution	units	reference / comment
BodyWeight Body mass	LN(GM=$f(x)$, GSD=$f(x)$)	kg	Inputs denoted as *f(x)* are calculated based on other outputs from the model and are documented in the Dose Assessment white paper
SoilIngestionRate Adult incidental soil ingestion rate	LN(GM=$f(x)$, GSD=$f(x)$, Min=0, Max=$f(x)$)	mg/day	*ibid.*
BeefIngestionRate_BWA Ingestion rate: "home-produced" beef	Gamma(μ=$f(x)$, σ=$f(x)$)	g/kg-day	*ibid.*
VentilationRateSleep_BWA Ventilation rate: sleeping	LN(GM=$f(x)$,GSD=$f(x)$)	m^3/min-kg	*ibid.*
ActivityDurationSleep_dist Daily exposure time: sleeping	LN(GM=$f(x)$, GSD=$f(x)$, Min=1, Max=24)	hr/day	*ibid.*
VentilationRateSedentary_BWA Ventilation rate: sedentary activity	LN(GM=$f(x)$,GSD=$f(x)$)	m^3/min-kg	*ibid.*
ActivityDurationSedSleep Daily exposure time: sedentary+sleeping	LN(GM=$f(x)$,GSD=$f(x)$)	hr/day	*ibid.*
VentilationRateLight_BWA Ventilation rate: light activity	LN(GM=$f(x)$,GSD=$f(x)$)	m^3/min-kg	*ibid.*
VentilationRateMedium_BWA Ventilation rate: moderate activity	LN(GM=$f(x)$,GSD=$f(x)$)	m^3/min-kg	*ibid.*
VentilationRateHeavy_BWA Ventilation rate: high activity	LN(GM=$f(x)$,GSD=$f(x)$)	m^3/min-kg	*ibid.*
ActivityDurationLight_UN Daily exposure time: light activity	LN(GM=$f(x)$,GSD=$f(x)$)	hr/day	*ibid.*
ActivityDurationMedium_UN Daily exposure time: moderate activity	LN(GM=$f(x)$,GSD=$f(x)$)	hr/day	*ibid.*
ActivityDurationHeavy_UN Daily exposure time: high activity	LN(GM=$f(x)$,GSD=$f(x)$)	hr/day	*ibid.*

8.4.2 \Exposure_Dose\Dose_Calculations\Physiology_SportOHV

Table 78. Attributes of inter-individual uncertainty in physiological characteristics for Sport OHV receptors

GoldSim element	value or distribution	units	reference / comment
Age	N(μ=25.7, σ=20.3, min = 16, max = 60)	yr	See Dose Assessment white paper
Gender	Male 60.8%, Female 39.2%	—	*ibid.*
BodyWeight Body mass	LN(GM=*f*(*x*), GSD=*f*(*x*))	kg	Inputs denoted as *f(x)* are calculated based on other outputs from the model and are documented in the Dose Assessment white paper
SoilIngestionRate Adult incidental soil ingestion rate	LN(GM=*f*(*x*), GSD=*f*(*x*), Min=0, Max=*f*(*x*))	mg/day	*ibid.*
VentilationRateSleep_BWA Ventilation rate: sleeping	LN(GM=*f*(*x*),GSD=*f*(*x*))	m^3/min-kg	*ibid.*
ActivityDurationSleep_dist Daily exposure time: sleeping	LN(GM=*f*(*x*), GSD=*f*(*x*), Min=1, Max=24)	hr/day	*ibid.*
VentilationRateSedentary _BWA Ventilation rate: sedentary activity	LN(GM=*f*(*x*),GSD=*f*(*x*))	m^3/min-kg	*ibid.*
ActivityDurationSedSleep Daily exposure time: sedentary+sleeping	LN(GM=*f*(*x*),GSD=*f*(*x*) 1.09 or 1.08)	hr/day	*ibid.*
VentilationRateLight_BWA Ventilation rate: light activity	LN(GM=*f*(*x*),GSD=*f*(*x*))	m^3/min-kg	*ibid.*
VentilationRateMedium_BWA Ventilation rate: moderate activity	LN(GM=*f*(*x*),GSD=*f*(*x*))	m^3/min-kg	*ibid.*
VentilationRateHeavy_BWA Ventilation rate: high activity	LN(GM=*f*(*x*),GSD=*f*(*x*))	m^3/min-kg	*ibid.*
ActivityDurationLight_UN Daily exposure time: light activity	LN(GM=*f*(*x*),GSD=*f*(*x*))	hr/day	*ibid.*

GoldSim element	value or distribution	units	reference / comment
ActivityDurationMedium_UN Daily exposure time: moderate activity	LN(GM=*f*(*x*),GSD=*f*(*x*))	hr/day	*ibid.*
ActivityDurationHeavy_UN Daily exposure time: high activity	LN(GM=*f*(*x*),GSD=*f*(*x*))	hr/day	*ibid.*

8.4.3 \Exposure_Dose\Dose_Calculations\Physiology_Hunter

Table 79. Attributes of inter-individual uncertainty in physiological characteristics for Hunter receptors

GoldSim element	value or distribution	units	reference / comment
Age Age	N(μ=25.7, σ=20.3, min = 16, max = 60)	yr	See Dose Assessment white paper
Gender Gender	Male 60.8%, Female 39.2%	—	*ibid.*
BodyWeight Body weight	LN(GM=*f*(*x*), GSD=*f*(*x*))	kg	Inputs denoted as *f(x)* are calculated based on other outputs from the model and are documented in the Dose Assessment white paper, Section 1.0.
SoilIngestionRate Adult incidental soil ingestion rate	LN(GM=*f*(*x*), GSD=*f*(*x*), Min=0, Max=*f*(*x*))	mg/day	*ibid.* function of age
GameIngestionRate_BWA Ingestion rate: “home-produced” game	Gamma(μ=*f*(*x*), σ=*f*(*x*))	g/kg-day	*ibid.*
VentilationRateSleep_BWA Ventilation rate: sleeping	LN(GM=*f*(*x*),GSD=*f*(*x*))	m^3/min-kg	*ibid.*
ActivityDurationSleep_dist Daily exposure time: sleeping	LN(GM=*f*(*x*), GSD=*f*(*x*), Min=1, Max=24)	hr/day	*ibid.*
VentilationRateSedentary_BWA Ventilation rate: sedentary activity	LN(GM=*f*(*x*),GSD=*f*(*x*))	m^3/min-kg	*ibid.*

GoldSim element	value or distribution	units	reference / comment
ActivityDurationSedSleep Daily exposure time: sedentary+sleeping	LN(GM=$f(x)$,GSD=$f(x)$)	hr/day	*ibid.*
VentilationRateLight_BWA Ventilation rate: light activity	LN(GM=$f(x)$,GSD=$f(x)$)	m^3/min-kg	*ibid.*
VentilationRateMedium_BWA Ventilation rate: moderate activity	LN(GM=$f(x)$,GSD=$f(x)$)	m^3/min-kg	*ibid.*
VentilationRateHeavy_BWA Ventilation rate: high activity	LN(GM=$f(x)$,GSD=$f(x)$)	m^3/min-kg	*ibid.*
ActivityDurationLight_UN Daily exposure time: light activity	LN(GM=$f(x)$,GSD=$f(x)$)	hr/day	*ibid.*
ActivityDurationMedium_UN Daily exposure time: moderate activity	LN(GM=$f(x)$,GSD=$f(x)$)	hr/day	*ibid.*
ActivityDurationHeavy_UN Daily exposure time: high activity	LN(GM=$f(x)$,GSD=$f(x)$)	hr/day	*ibid.*

8.4.4 \Exposure_Dose\Dose_Calculations\ExposureTime_Rancher

Table 80. Attributes of inter-individual uncertainty in physiological characteristics for Rancher receptors – Exposure Time

GoldSim element	value or distribution	units	reference / comment
ET_Ranch_DayTrip Ranchers; day trip time in exposure area	U(min=4, max=12)	hr/day	See Dose Assessment white paper
ET_Overnight Exposure frequency, overnight trips	24	hr/day	*ibid.*
ET_Camp_OnsiteFrac All receptors; fraction of camp trip exposure time on disposal cell	U(min=0.25, max=0.75)	—	*ibid.*
OHV_timeFrac_Camper All receptors; camp trip time spent OHVing	U(min=2, max=8)	hr/day	*ibid.*

GoldSim element	value or distribution	units	reference / comment
OHV_timeFrac_HuntRanch_DayTrip Hunter/Rancher; fraction of day trip time spent OHVing	U(min=0.1, max=0.75)	hr/day	*ibid.*
EF_Ranch_dist Rancher; exposure frequency	beta(μ=135, σ=34.9, min = 0, max = 180)	day/yr	*ibid.*
Frac_Ranch_Overnight_dist Ranchers; fraction of exposure frequency related to overnight trips	U(min=0.5, max=0.67)	—	*ibid.*

8.4.5 \Exposure_Dose\Dose_Calculations\ExposureTime_SportOHV

Table 81. Attributes of inter-individual uncertainty in physiological characteristics for Sport OHV receptors – Exposure Time

GoldSim element	value or distribution	units	reference / comment
ET_Rec_DayTrip Sport OHVers; day trip time in exposure area	beta(μ=6.3, σ=2.11, min = 1, max = 20)	hr/day	See Dose Assessment white paper
ET_Overnight Exposure frequency, overnight trips	24	hr/day	*ibid.*
ET_Camp_OnsiteFrac All receptors; fraction of camp trip exposure time on disposal cell	U(min=0.25, max=0.75)	—	*ibid.*
OHV_timeFrac_Camper All receptors; camp trip time spent OHVing	U(min=2, max=8)	hr/day	*ibid.*
EF_Recreational_dist Sport OHVer; exposure frequency	LN(GM=11.3, GSD=3.45, Min=1, Max=200)	d/yr	*ibid.*
Frac_recOHV_Overnight_dist Sport OHVers; fraction of exposure frequency related to overnight trips	U(min=0, max=1)	—	*ibid.*

8.4.6 \Exposure_Dose\Dose_Calculations\ExposureTime_Hunter

Table 82. Attributes of inter-individual uncertainty in physiological characteristics for Hunter receptors – Exposure Time

GoldSim element	value or distribution	units	reference / comment
ET_Rec_DayTrip Sport OHVers; day trip time in exposure area	beta(μ=6.3, σ=2.11, min = 1, max = 20)	hr/day	See Dose Assessment white paper
ET_Overnight Exposure frequency, overnight trips	24	hr/day	*ibid.*
ET_Hunt_DayTrip_OnsiteFrac Hunter; fraction of hunting day trip exposure time on disposal cell	U(min=0.02, max=0.17)	—	*ibid.*
ET_Camp_OnsiteFrac All receptors; fraction of camp trip exposure time on disposal cell	U(min=0.25, max=0.75)	—	*ibid.*
OHV_timeFrac_Camper All receptors; camp trip time spent OHVing	U(min=2, max=8)	hr/day	*ibid.*
OHV_timeFrac_HuntRanch_DayTrip Hunter/Rancher; fraction of day trip time spent OHVing	U(min=0.1, max=0.75)	—	*ibid.*
EF_Hunting_dist Hunter; exposure frequency	LN(GM=4.66, GSD=3.45, min=1, max=100)	day/yr	*ibid.*
Frac_Hunt_Overnight_dist Hunters; fraction of exposure frequency related to overnight trips	U(min=0, max=1)	—	*ibid.*
EF_Recreational_dist Sport OHVer; exposure frequency	LN(GM=11.3, GSD=3.45, min=1, max=200)	day/yr	*ibid.*

8.4.7 \Exposure_Dose\Dose_Calculations\Population_Size_Variables

Table 83. Attributes of population variability.

GoldSim element	value or distribution	units	reference / comment

GoldSim element	value or distribution	units	reference / comment
Number_Individuals_Total Total number of individuals in vicinity of site, per year	Tri(100, 350, 500)	—	See Dose Assessment white paper
Ranch_Hands_dist Number of ranchers in vicinity of site, per year	U(1, 20)	—	*ibid.*
Ranchers_Picker This element is used to identify the number of ranch receptors present.	Binomial(Batch Size = 1, Probability = $f(x)$/20)	—	For probability, the denominator corresponds to the size of the receptor array and *f(x)* to the value of Ranch_Hands_dist.
Number_Hunter Number of hunters in vicinity of site, per year	Binomial(Batch Size = round(Number_Individuals_Total – Number_Ranch_Hands), Probability = 0.25)	—	See Dose Assessment white paper
Hunters_Picker This element is used to identify the number of hunter receptors present.	Binomial(Batch Size = 1, Probability = Number_Hunter/175)	—	Analogous to Ranchers_Picker.
Number_Recreationalists Number of recreationalists in vicinity of site	$f(x)$ = Number_Individuals_Total - Ranch_Hands_Dist	—	See Dose Assessment white paper
Number_SportOHV Number of OHVers in vicinity of site	$f(x)$ = Number_Recreationalists - Number_Hunter	—	See Dose Assessment white paper
SportOHVers_Picker This element is used to identify the number of SportOHV receptors present.	Binomial(Batch Size = 1, Probability = Number_SportOHV/424)	—	Analogous to Ranchers_Picker.

8.4.8 \Exposure_Dose\Dose_Calculations\UraniumHazard

Table 84. Uranium hazard for Rancher and Recreationists.

GoldSim element	value or distribution		units	reference / comment
Uranium_RfD Reference dose for uranium	Probability	Value		See Dose Assessment white paper
	0.5	0.0006	mg/kg-day	

GoldSim element	value or distribution		units	reference / comment
	0.5	0.0030	mg/kg-day	

8.4.9 \Exposure_Dose\Dose_Calculations\OffSite_Receptors

Table 85. Inhalation dose for off-site receptors.

GoldSim element	value or distribution	units	reference / comment
ET_RestArea Exposure time rest area caretaker	24	hr/day	See Dose Assessment white paper
EF_RestArea Exposure frequency rest area caretaker	Tri(327, 350, 365)	day/yr	*ibid.*
ET_Knolls Exposure time for day trip, Knolls OHVer	Beta(μ=6.3, σ=2.11, min=1, max=20)	hr/day	*ibid.*
EF_Knolls Exposure frequency, Knolls OHVer	LN(μ=11.3, σ=3.45, min=1, max=200)	day/yr	*ibid.*
ET_Traveller Exposure time travelers on I-80 and train	U(2.3, 7.2)	min/day	*ibid.*
EF_Traveller Exposure frequency I-80 and west-side access road traveller	U(250, 365)	day/yr	*ibid.*
ET_UTTR_Road Exposure time cars on west-side access road (Utah Test and Training Range access)	U(2.4, 4.0)	min/day	*ibid.*

8.4.10 \Exposure_Dose\Screening_Calculations

Table 86. Parameters used in screening dose calculations.

GoldSim element	value or distribution	units	reference / comment
NativePlant_Ing_Rate	1	kg/yr	See Dose Assessment white paper
FreshWeightConversion	U(0.05, 0.3)	—	*ibid.*

GoldSim element	value or distribution	units	reference / comment
OffsiteWater_Ing_Rate	1	L/yr	*ibid.*

9.0 \GWPLs

The model estimates concentrations in a hypothetical monitoring well down gradient of the waste embankment. Certain radionuclides are of interest, and their concentrations are displayed for comparison to Ground Water Protection Limits (GWPLs) as specified in State of Utah (2010) Table 1A.

Table 87. Groundwater protection limits.

GoldSim element	value or distribution	units	reference / comment
MaxTime_WellConcs	500	yr	State of Utah (2010)
GWPL_Sr90	42	pCi/L	*ibid.*
GWPL_Tc99	3790	pCi/L	*ibid.*
GWPL_I129	21	pCi/L	*ibid.*
GWPL_Th230	83	pCi/L	*ibid.*
GWPL_Th232	92	pCi/L	*ibid.*
GWPL_Np237	7	pCi/L	*ibid.*
GWPL_U233	26	pCi/L	*ibid.*
GWPL_U234	26	pCi/L	*ibid.*
GWPL_U235	27	pCi/L	*ibid.*
GWPL_U236	27	pCi/L	*ibid.*
GWPL_U238	26	pCi/L	*ibid.*

10.0 DeepTimeScenarios

Deep time scenarios are developed to provide information for a qualitative analysis of effects from the Clive Facility on future conditions after 10,000 years.

Table 88. Deep time scenario parameters.

GoldSim element	value or distribution	units	reference / comment
Unit_U238	vector by species with 0's for all except U238, with 1 g	g	Used to explore U238 decay and ingrowth of daughters

GoldSim element	value or distribution	units	reference / comment
LargeLakeStart	LN(GM=14000, GSD=1.2, min=0, max=50000)	yr	see Deep Time Assessment white paper
LargeLakeEnd	LN(GM=6000, GSD=1.2, min=0, max=50000)	yr	*ibid.*
LargeLakeSedimentationRate	LN(GM=0.00012, GSD=1.2)	m/yr	*ibid.*
IntermediateLakeDuration	LN(GM=500, GSD=1.5, min=0, max=2500)	yr	*ibid.*
IntermediateLakePoissonRate	$f(x)$	1/yr	*ibid.*
IntermediateLake SedimentAmount	LN(GM=2.82, GSD=1.71)	m	*ibid.*
SiteDispersalArea	LN(GM= VolumeAboveGrade / 0.1 m, GSD=1.5, min= VolumeAboveGrade / 1 m, max=Large)	km^2	*ibid.*
IntermediateLakeDepth	beta(μ=30, σ=18, min = 0, max = 100)	m	*ibid.* resampled at each intermediate lake event
LargeLakeDepth	beta(μ=150, σ=20, min = 100, max = 200)	m	*ibid.* resampled at each large lake recurrence

11.0 References

Kocher, D.C., 1981. *Radioactive Decay Data Tables*, DOE/TIC-11026, Technical Information Center, U.S. Dept. of Energy, Washington, DC.

Tuli, J.K., 2005, Nuclear Wallet Cards, National Nuclear Data Center. Brookhaven National Laboratory. Seventh edition, April 2005.