

A Generic Performance Assessment (PA) GoldSim Model

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Objective

Objective: Introduction to probabilistic performance assessment (PPA) models in GoldSim so that the West Valley PPA GoldSim Model is easier to understand.

When the West Valley PPA Model is released, a GoldSim Player model version will be available to everyone to open and examine.

Before the West Valley PPA Model is available, anyone can view the Generic PA Model as an example of a performance assessment model in GoldSim.



Agenda

1. Performance Assessment Overview
2. Generic PA Conceptual Site Model
3. Structure of the Generic PA model
4. Dashboards in the Generic PA model
5. Generic PA model results



What is a Performance Assessment?

- Performance Assessments evaluate potential future impacts of radionuclides to human and ecological health.
- Health impacts are compared to regulatory requirements for site closure and license termination.
- For the West Valley Site, the Performance Assessment will be used to support Phase 2 decisionmaking.



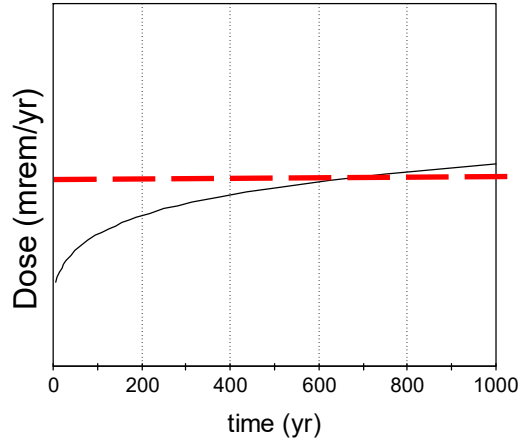
What is a Probabilistic PA Model?

- Performance Assessment models evaluate the release and movement of radionuclides from a site into the environment, in soil, water, and air.
- They also estimate the potential exposure and risk to humans from these radionuclides for long times into the future.
- Probabilistic models include uncertainty in the model inputs that gets carried through the model to provide uncertainty in the output.

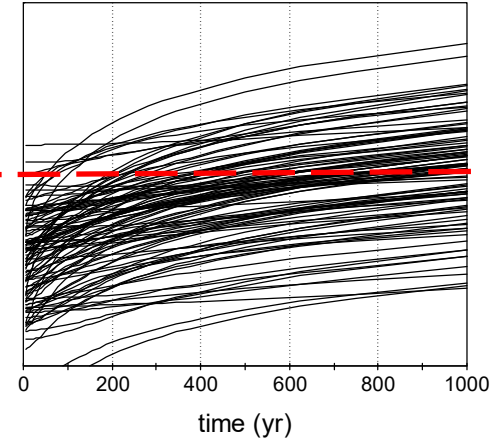


Deterministic vs. Probabilistic Models

Single deterministic realization



Many probabilistic realizations

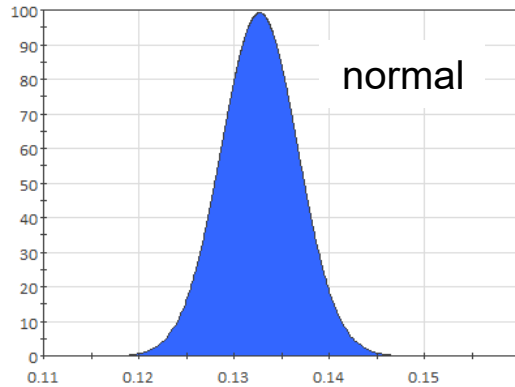


- Does not represent uncertainty
- Decision appears clearer than it really is

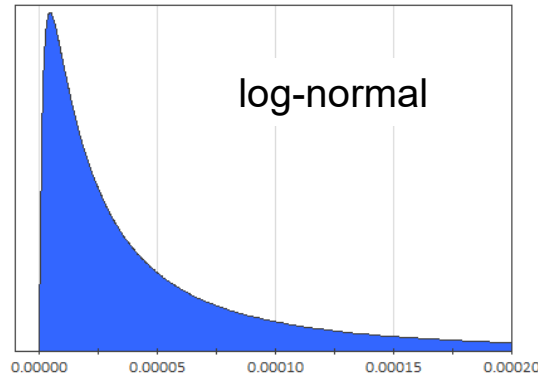
- Reflects uncertainty clearly
- Decision maker has to evaluate comfort level



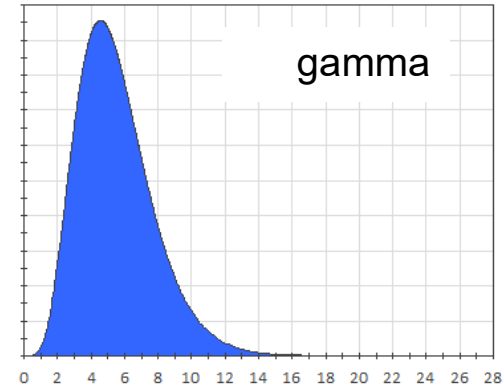
Many Types of Distributions are Available to Represent Uncertainty



gully advance rate



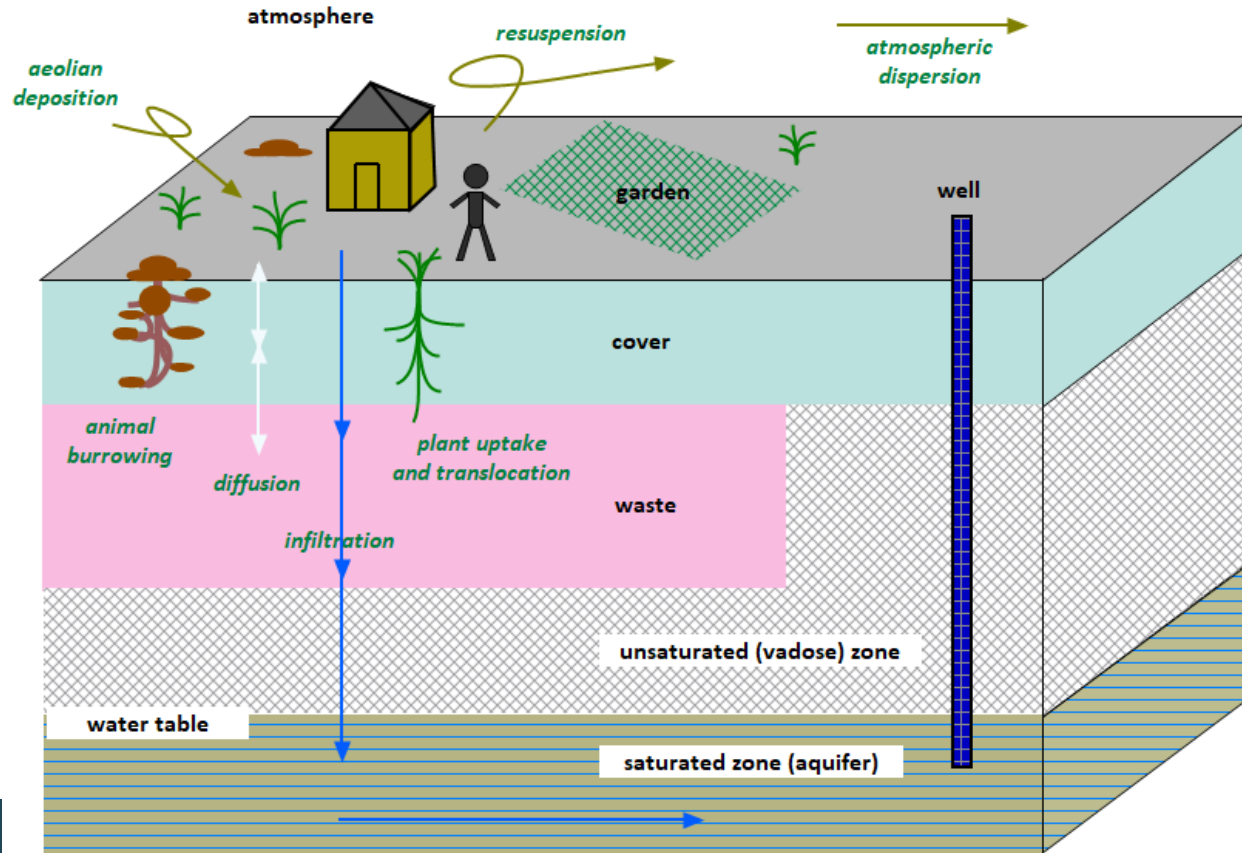
uranium solubility



Pu-242 inventory

Distributions are developed based on site and other representative data.

Generic PA Conceptual Site Model



A Generic Radiological Performance Assessment Model for a Radioactive Waste Disposal Site* (RWDS)

*The RWDS is a fictitious site conjured simply as a modeling demonstration. Resemblance to any real radioactive waste site is unintentional.

Inputs

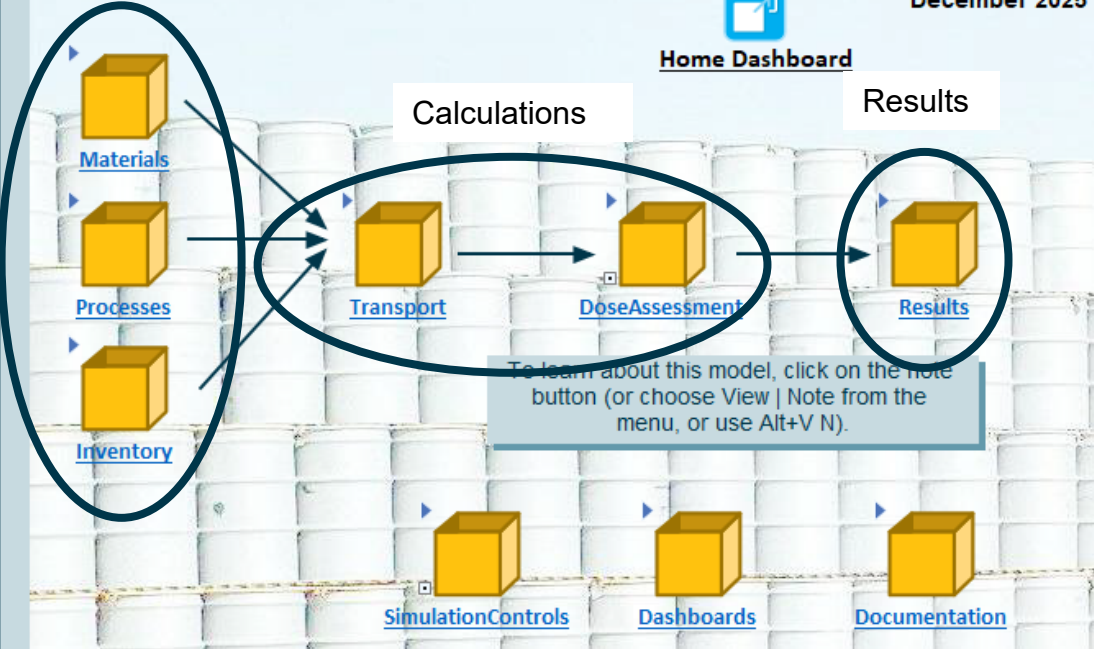
version 3.2
December 2025



Home Dashboard

Calculations

Results



Built using GoldSim version: 15 R1

Generic PA GoldSim Model

The Generic PA model main page shows a high-level view of the model via the yellow GoldSim containers.



Browser

Model Materials

Model

- Acknowledgements
- Dashboards
- Documentation
- DoseAssessment
- Inventory
- Materials
 - AirDiffusivities
 - DecayChains
 - KhAirWater
 - RockProperties
 - SoilKds
 - SoilProperties
 - Solubilities
 - WasteProperties
 - WaterProperties
- Processes
- Results
- SimulationControls
- Transport

Materials and species definitions

This container includes definitions of contaminant species and their decay rates, and the material properties of the physical materials making up the solid porous media Soil and Rock, and the fluid media Air and Water.

Contaminant Species

This list of typical LLW contaminant radionuclide species is defined in the Species element.

Species

DecayChains

Porous media Soil and Rock

Properties of an unsaturated porous medium, including porosity, bulk density, etc., are defined in SoilProperties. Soil/Water partition coefficients are in Kds. Porosity is used to calculate air and water content and tortuosity in air and water. Tortuosity in the Solid definition is set equal to 1, since this is calculated explicitly for purposes of phase-specific advective and diffusive transport.

Soil

SoilProperties

SoilKds

Rock

RockProperties

RockKds

Similar properties are defined for Rock. If different Kds are to be used for Rock, then a separate (localized) container should be used for their definition.

Waste - a specialized solid medium

The Waste medium occupies the waste cells. For now, it has the same properties as Soil, but this can be changed in WasteProperties.

Waste

WasteProperties

Water - the reference fluid

Properties of Water, which is present in amount in all Cell elements in the model.

Water

WaterProperties

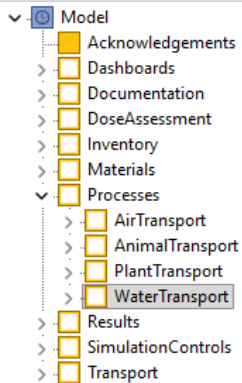
Solubilities

APPLICA
This Spec
modifica
particula
Typically
with half
5 years a
Rn-222 is

Model Inputs: Materials

This container holds the input values and distributions for properties of the water, air, natural materials, and the waste.

The Species element includes all the radionuclides in the model.



Contaminant transport modeling

The model assumes that all contaminants exist only in the waste cells at the time the model begins its calculations. All other cells, aquifers and pipes are contaminant-free at time zero. The structure of the model is dimensionally static, that is, the sizes of the Pathway Elements do not change through the simulation time, but the contaminants move with the various processes that are set up in the model. The simulation calculates and monitors the migration of these contaminants.

Transport of contaminants through the environment occurs as the result of several mechanisms, including porous medium advection (water flow) and diffusion, atmospheric advection and dispersion (air movement above the waste to offsite locations), and biotically-induced transport. Elements defining contaminant transport parameters common to all waste disposal configurations are in the following containers. Switches governing which processes are active are in SimulationSettings.



[Switch Dashboard](#)



AirTransport

Airborne contaminant transport includes diffusion in the air space in the porous medium and into the atmosphere, as well as aeolian transport offsite.



WaterTransport

Water, in which contaminants will dissolve to varying degrees, is hypothesized to advect downward from the ground surface, through the waste cells, and down to the saturated zone. Water then moves horizontally in the aquifer to a drinking water well. Diffusion in the water phase is ignored under the assumption that advection-dispersion is the dominant contaminant transport process.



PlantTransport

Plant-induced transport of contaminants is assumed to take in contaminants through the roots and redistribute them to the aboveground tissues of the plant (the "shoots"). Upon senescence, these aboveground plant parts are incorporated into surface soils.



AnimalTransport

Burrowing (fossorial) animals transport bulk materials (the soil, waste and associated water and air) through burrow excavation and collapse. Excavations transport contaminants directly to the surface, while collapse moves materials downward from one layer to the next one below.

Model Inputs: Processes

This container holds the inputs for transport processes included in the Generic PA model.

Transport processes include contaminant movement in air and water, and by plants and animals.

Browser

Model

- Acknowledgements
- Dashboards
- Documentation
- DoseAssessment
- Inventory
 - ConcInventory_perMass
 - ConcInventory_perVol
 - ConcInventory_TransUranics
 - InventoryMass
 - InventoryMean
 - InventorySD
 - InventoryValue
 - IsTRU
 - Mass_Waste
 - MassBySpecies
 - rMassConc by Spp
 - rVolConc by Spp
 - TotalMass
 - TRUScreen_AtomicNumber
- Materials
- Processes
- Results
- SimulationControls
- Transport

Model ▶ Inventory

Low level waste radionuclide inventory

Inventory is defined with a probability (gamma) distribution, sampled independently, and programmed vector by Species (radionuclide).

It is assumed that data exist for inventory, such that a mean and standard deviation are developed for radionuclides, applied to a gamma distribution.



InventoryMean

Mean value of the inventory distribution, as a vector by radionuclide

Surrounding the mean is uncertainty. For the gamma distribution, the standard deviation (SD) is developed for each Species (radionuclide).



InventorySD

In this implementation, each Species is a gamma distribution, though these could be defined as other distributions, as expressions, as correlated distributions, or by other means.

Activities are assumed at closure, which is when time=0.



InventoryValue

The stochastic definition of inventory is defined using a single Stochastic element, dimensioned by Species.

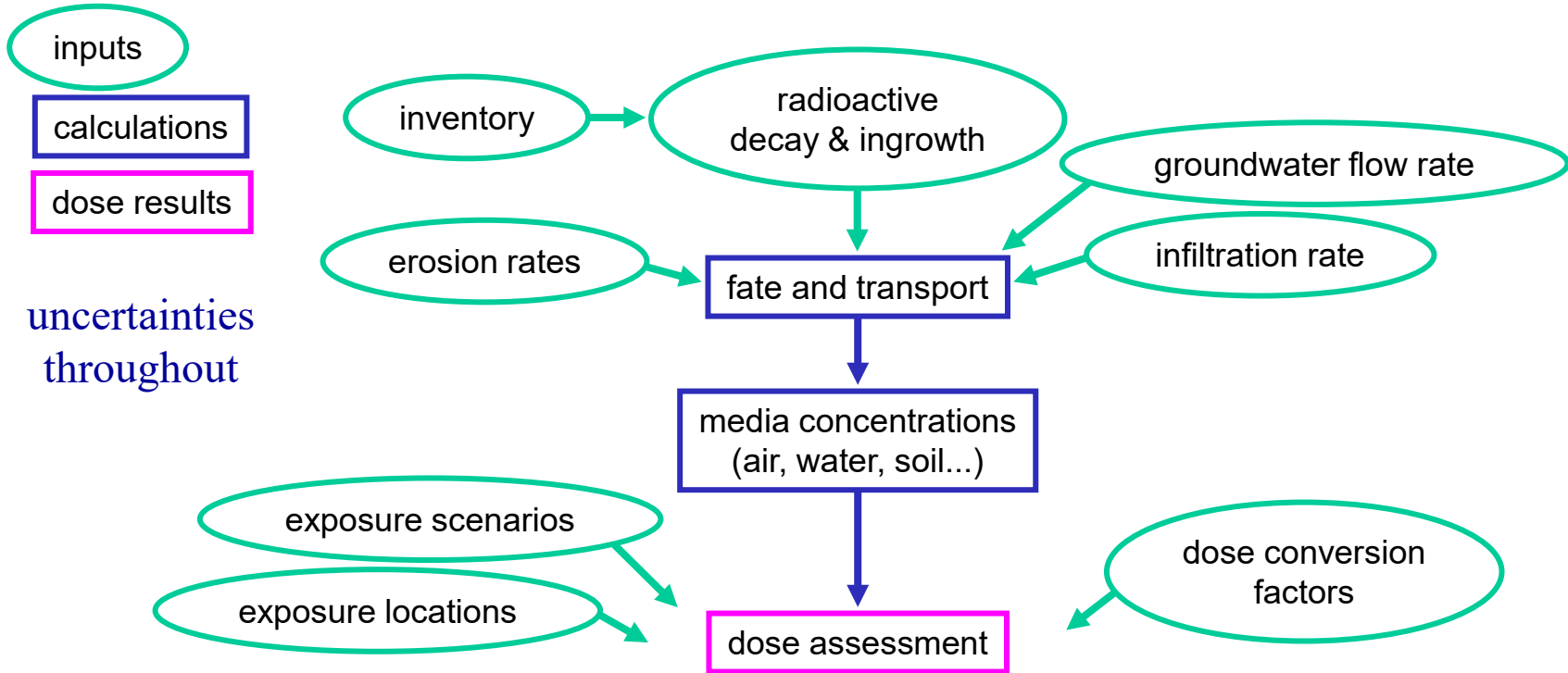
Model Inputs: Inventory

Inventory distributions are developed for each radionuclide in the model.

Inventory is tracked from the time of disposal to release and transport through the environment.



Example PA Influence Diagram



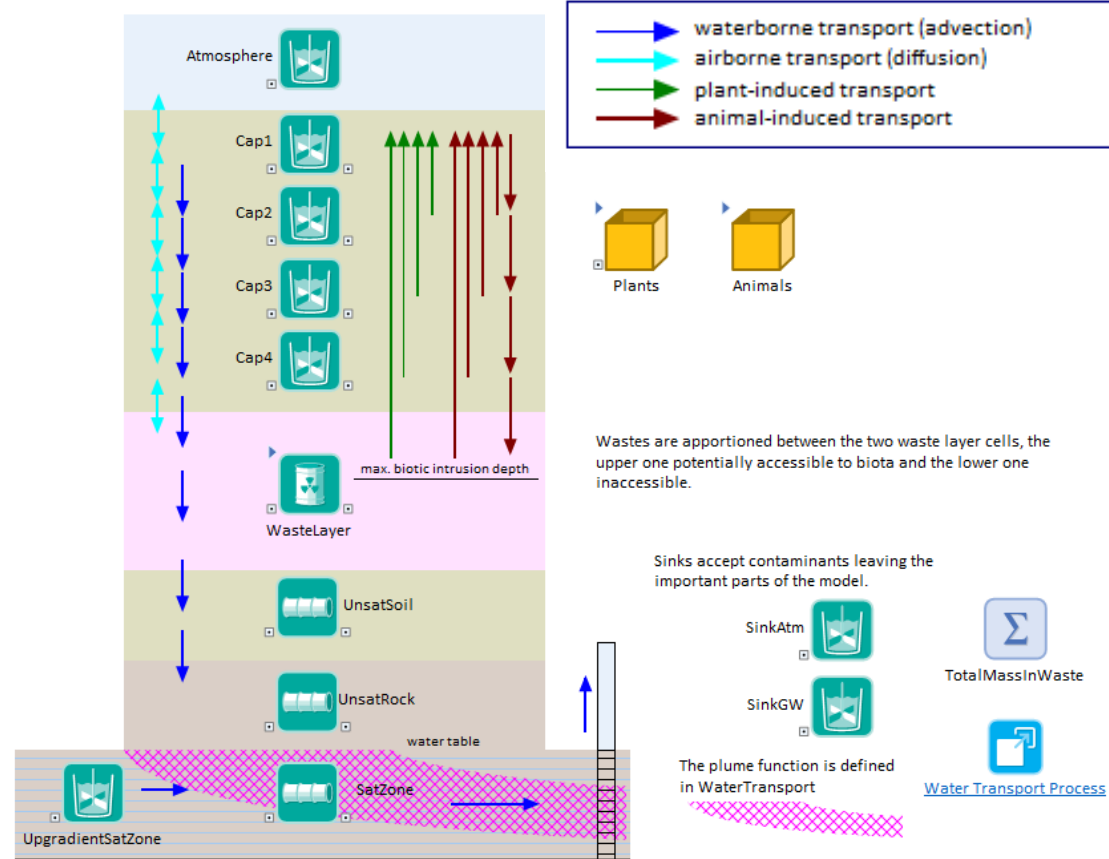
This collection of pathways (cells and pipes) represents a 1-D column for modeling transport from the wastes to receptor exposure media, including surface soils (Cap1) and a drinking water well. Transport mechanisms include air, water, and biotic processes. These mechanisms are defined in the Processes container.

Waste inventory is defined in the Inventory container.

Transport Column

Contaminants are allowed to move upwards and downwards in this 1D column of teal cells.

Visually see what calculations are being done in the model through the use of graphics.



Browser

Model

- Acknowledgements
- Dashboards
- Documentation
- DoseAssessment
 - Activities
 - DCFs
 - ExposureMediaConc
 - PlantCRFood
 - Resident
 - TEDE_Ext
 - TEDE_Ing_Animal
 - TEDE_Ing_Plant
 - TEDE_Ing_Soil
 - TEDE_Ing_Water
 - TEDE_Inh
 - TEDE_Inh_Gas
 - TEDEAir
 - TEDEAll
 - Time_of_Access
 - Total_Ing_Sum
 - Total_Ing_Sum_ByPathway
 - TotalTEDE_Ext
 - TotalTEDE_Ing_Animal
 - TotalTEDE_Ing_Plant
 - TotalTEDE_Ing_Soil
 - TotalTEDE_Ing_Water
 - TotalTEDE_Inh
 - TotalTEDE_Inh_Gas
 - TotalTEDE_Inh_GasAndParticles
 - TotalTEDEAir
 - TotalTEDEAll
 - TotalTEDEAll_NoWater
- Transient
- Inventory
- Materials
- Processes
- Results
- SimulationControls
- Transport

Dose Assessment

This dose assessment illustrates how exposure to contamination could occur via natural processes. The Residential Scenario assumes a resident lives on top of the waste in a home with a slab, garbage produce on the site, and drinks water from a well 100-m downstream from the site. A lower risk Transient scenario is also implemented. No intrusion into the waste is included in scenarios or pathways. Other scenarios can be developed, as needed, to address site-specific requirements; details on these scenarios can be found in the note panes below.

The radiological assessment method calculates total effective dose equivalent (TEDE) as the product of a pathway dose conversion factor (PDCF) and the concentration of the radionuclides in soil or air obtained from the contaminant transport model. The PDCFs are derived from the method of Kennedy and Streng (1992) for converting residual contamination into TEDE.

General calculations

- ExposureMediaConc: Doses arise from exposures to contaminated media such as soil, water, and air. Concentrations in these exposure media are referenced in this container for use in the dose model.
- PlantCRFood: Element-specific plant/soil concentration ratio in units of concentration of contaminant in dried plant matter per concentration of contaminant in dried bulk soil. These are the same for all plant types involved in the plant ingestion pathway, but an independent set of plant CRs is used for plants involved in contaminant transport.
- DCFs: Dose conversion factors (DCFs) are used in converting media concentrations to dose.
- Activities: The receptors engage in various activities and behaviors that contribute to exposure. These are quantified here.

Dose calculations for specific receptors

- Transient: The transient occupant occasionally visits the site, but does not live there or ingest anything local.
- Resident: The resident farmer lives on the RWDS, and grows and consumes animal products for ingestion.

Dose Calculations

This container holds the calculations for radionuclide concentrations over time in air, soil, water, and other media.

These concentrations are used in human health dose and risk calculations.

Dose calculations include inhalation, ingestion and external pathway doses.

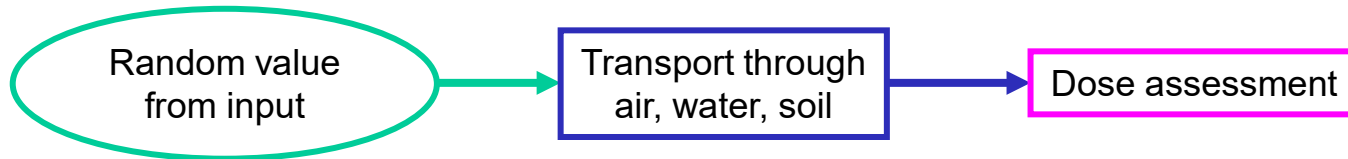
Run the Model

- Tell the GoldSim model how many years and how many realizations to run.
 - Run model simulations for 10,000 years
 - Run 1000 realizations of the model
- What is a realization?

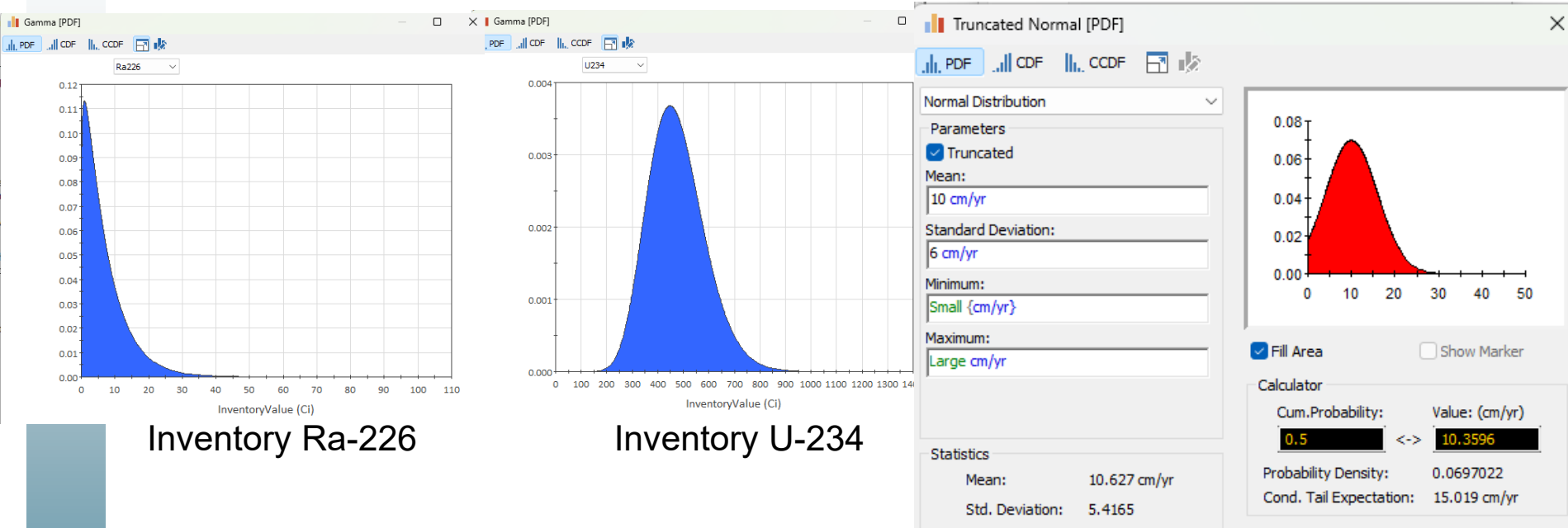


What is a Realization?

- A realization is a single run of the model through time.
- For each realization:
 - GoldSim chooses a random value from each input parameter distribution.
 - Calculations are performed in the model for waste moving in the soil, water and air.
 - Dose calculations are made each year after institutional control is lost.



Input Distributions in the Generic PA



Infiltration



Home Dashboard for the Generic PA Model

Controls for running the model

Simulation Switches

Switches are available to run the model in different ways and to test the influence of different processes.

Simulation Settings

GoldSim Simulation Settings is accessible through this button.

Access to results

Dose Results

This button takes you to the dose result dashboard.

Radon Performance

Radon performance, as a ground surface flux (per unit area) and as a concentration in air above the disposal unit, are accessed here.

Contaminant Flux

This button goes to the contaminant flux results dashboard.

Dynamic Results

Some dynamic results can be viewed through GoldSim dashboard output controls here.

Run Model

This button runs the model, as well as the play button in the menu bar. You can also run the model by pressing F5.

Browse Model

This button takes you to the top level of the model for model browsing.

Home Dashboard

The Home Dashboard connects the user to model simulation options, result dashboards and other helpful model links.



Dose Results Dashboard

1000 Realizations

Dose Time History Results

Total dose (excluding dose from Rn and progeny in air)

Average time to loss of Institutional Control: 100 yr

Simulation duration: 10000 yr

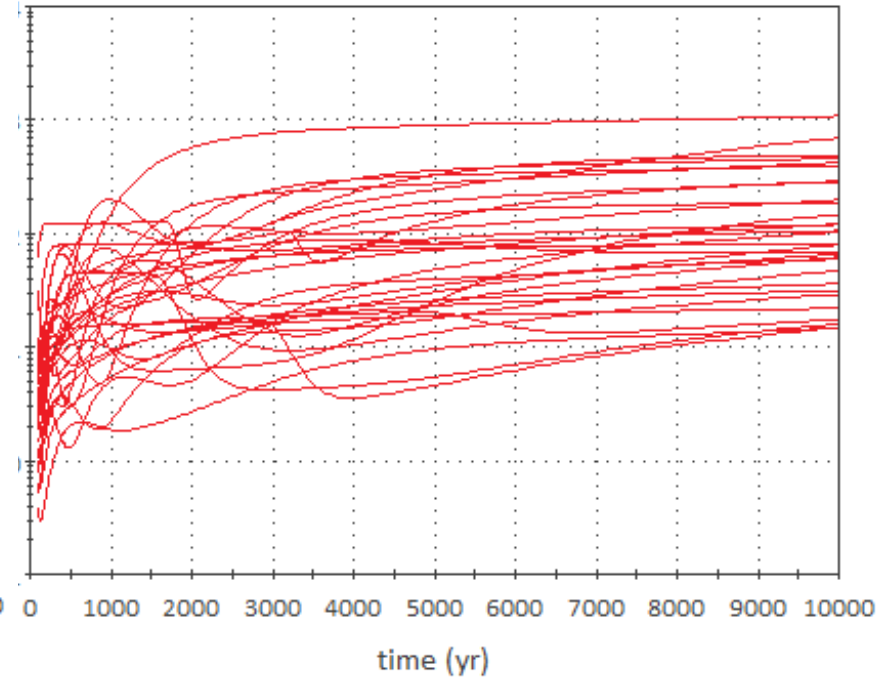
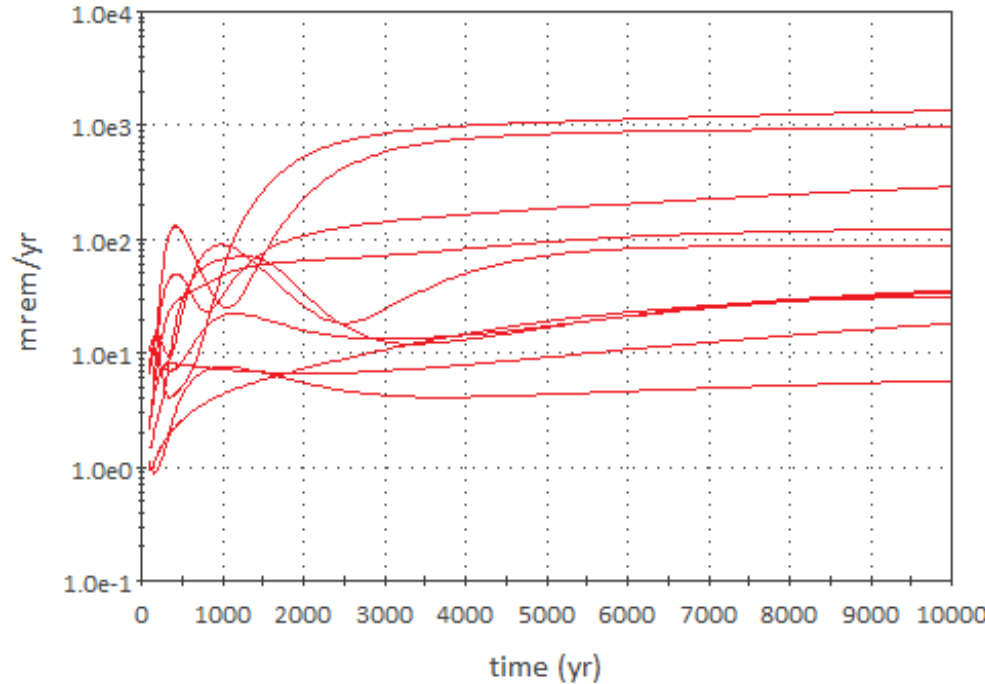
	Air pathway	Ingestion pathways	External pathways	Total dose
Resident farmer	Dose Time Histories	Dose Time Histories	Dose Time Histories	Dose Time Histories
	Dose by Radionuclide	Dose by Radionuclide	Dose by Radionuclide	Dose by Radionuclide
		Dose by Pathway		Dose by Pathway
Mean peak dose	0.0129 mrem/yr	222 mrem/yr	1.28 mrem/yr	223 mrem/yr
Mean peak time	3300 yr	8492 yr	8559 yr	8516 yr



Resident Dose Results

10 Realizations

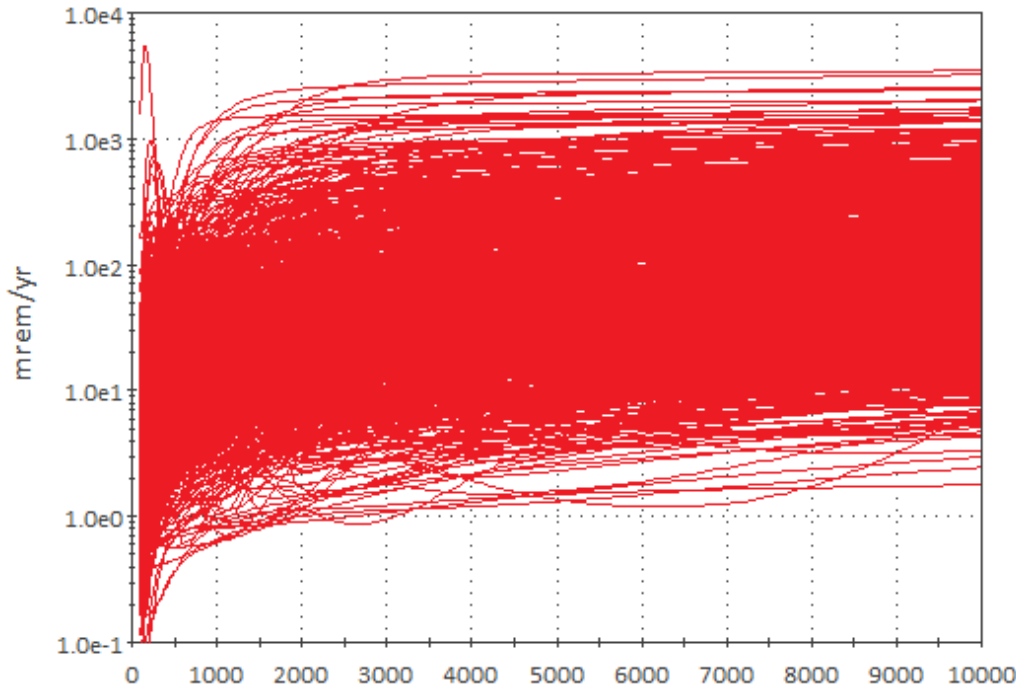
30 Realizations



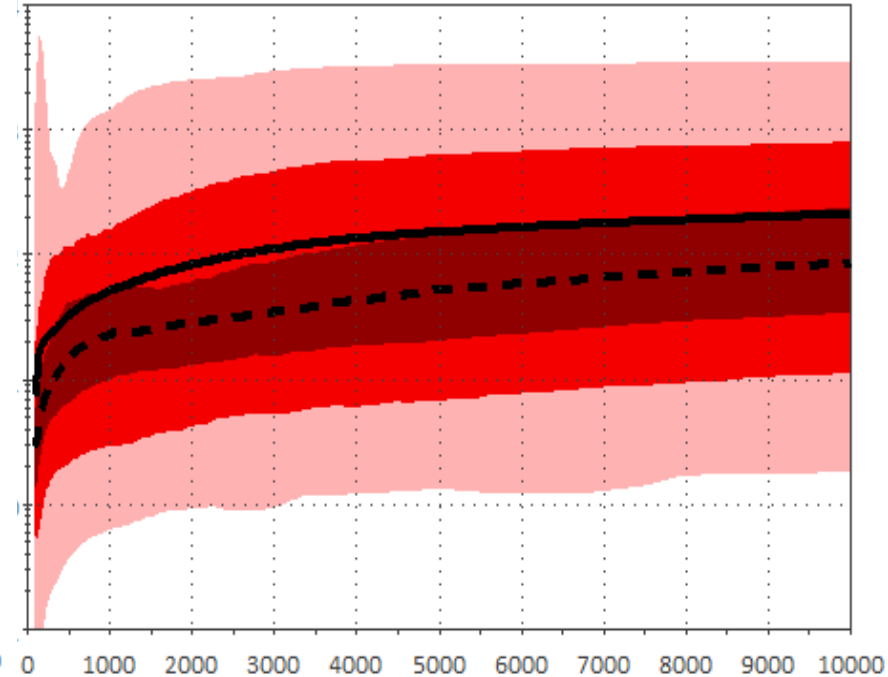
Resident Dose Results

1000 Realizations

All Realizations



Statistical Summary



Statistics for Total All Pathways Dose

Min..5% / 95%..Max

5%..25% / 75%..95%

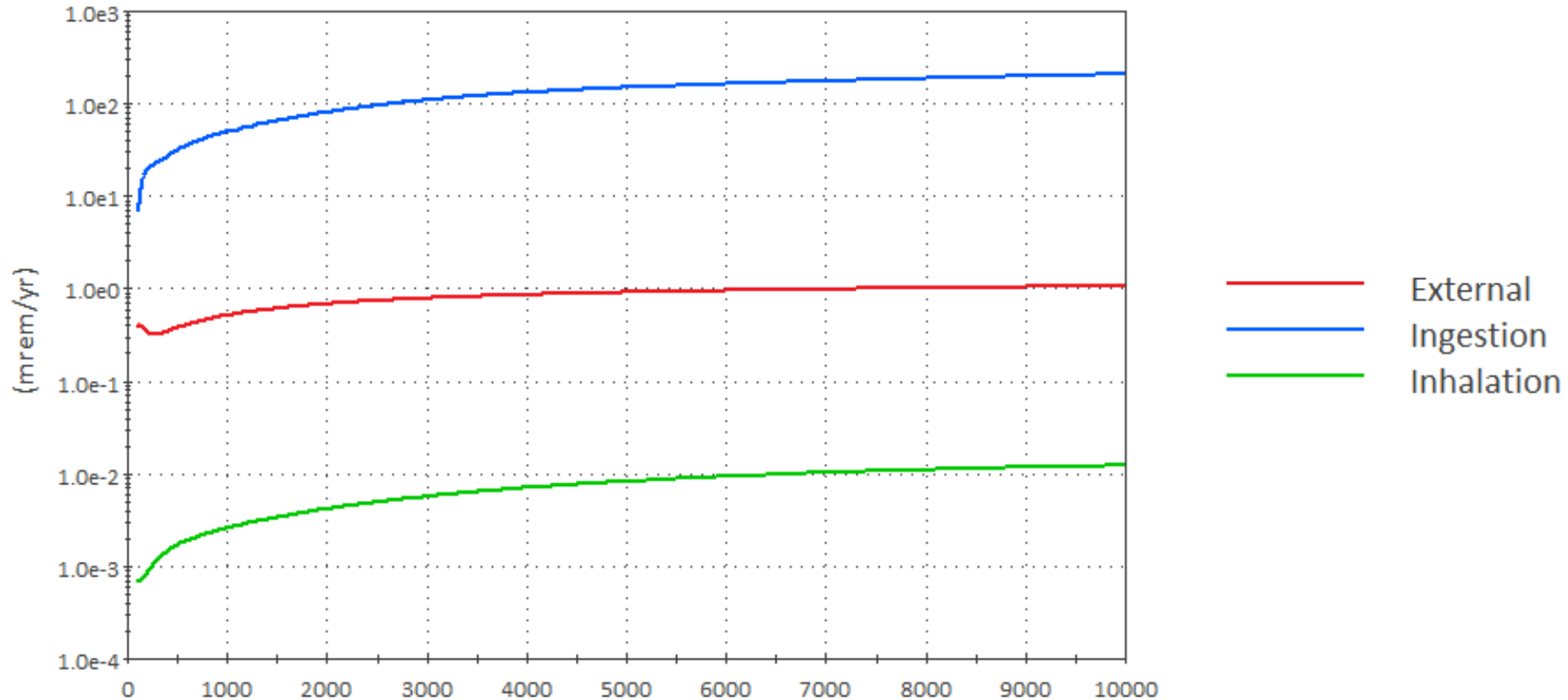
25%..75%

Mean

50%

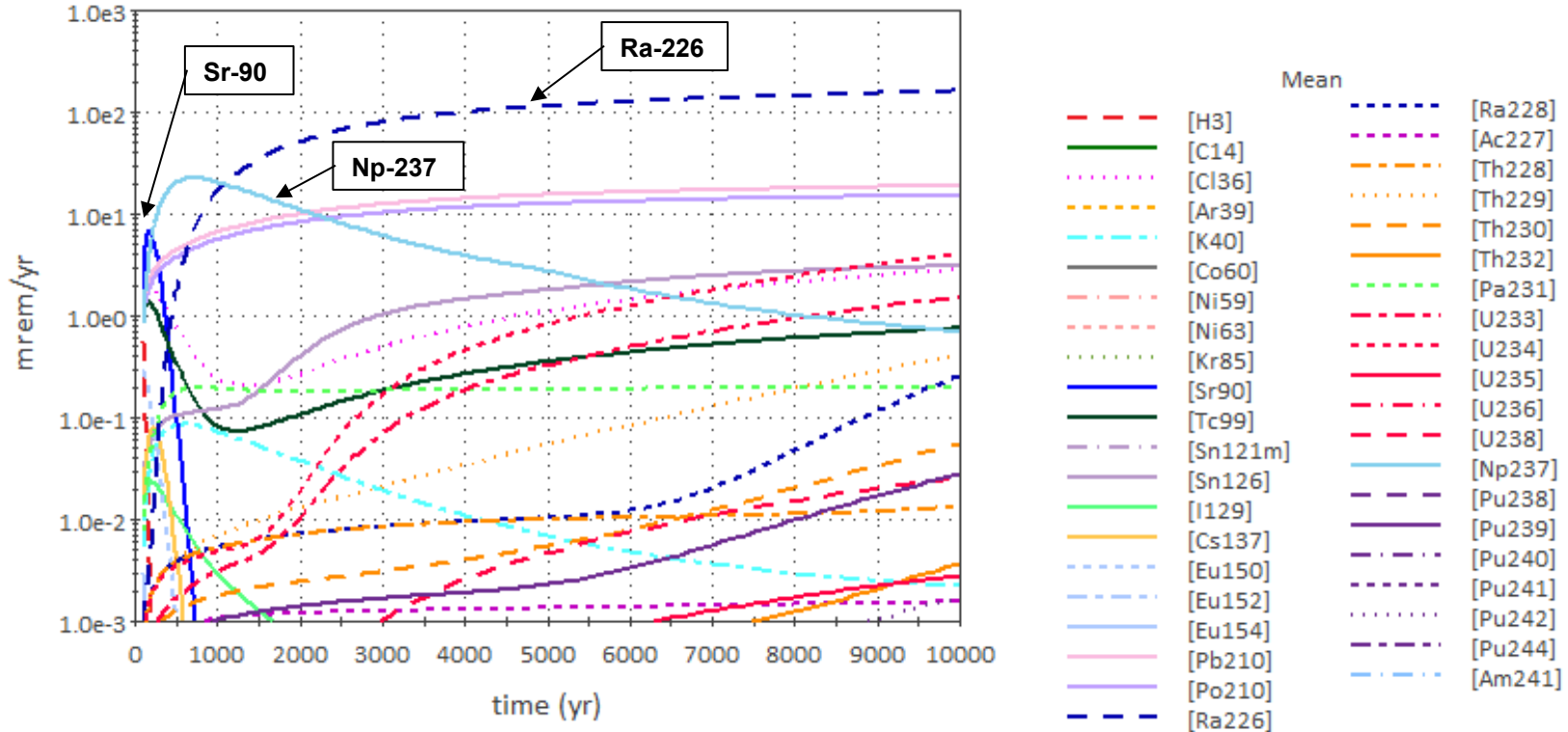
Average Dose Through Time by Pathway

1000 Realizations



Average Total Dose by Radionuclide

1000 Realizations



The GoldSim Player is available here:

www.goldsim.com/web/downloads

The Generic PA Model is available here:

www.neptuneinc.org/genericpa

