


Performance Assessment Modeling with GoldSim



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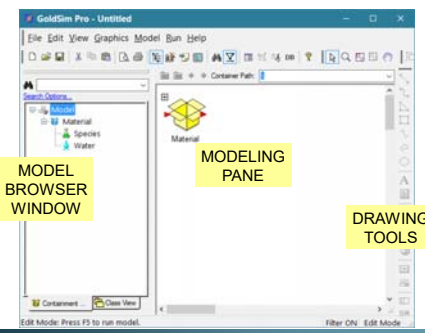
Presentation Outline

- Introduction to GoldSim
- Handling Uncertainty
- A GoldSim PA Example

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The GoldSim Interface



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GoldSim Basic Model Elements

-  **Data:** input of a fixed value
-  **Stochastic:** input of a distribution for a value
-  **Expression:** a mathematical expression
-  **Selector:** for building complex conditionals
-  **Event:** timed or triggered event and consequences
-  **Extremum:** for tracking maximum values
-  **Lookup Table:** input of a table of values

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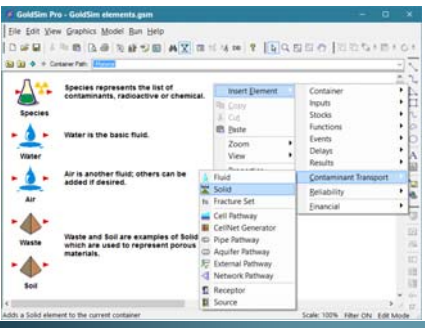
GoldSim PA Model Elements

-  **Species:** input of chemical and rad species
-  **Fluid:** definition of a fluid (in this case, water)
-  **Solid:** definition of a porous solid
-  **Source:** contaminant source
-  **Cell:** compartment containing materials
-  **Aquifer:** definition for simple groundwater transport
-  **Receptor:** definition of an exposed receptor

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Model Elements: Materials



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Model Elements: Pathways

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Edit Species: U238

A list of decay products is defined here.

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Many Types of Distributions are Available to Represent Uncertainty

uniform triangular discrete

normal log-normal gamma

What is chosen must have some basis in reality.

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Typical Results

Any state or condition of the model can be tracked and graphed through time (e.g. concentrations, flow rates, doses).

This could be concentration or dose.

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A Screenshot Tour of Neptune's Generic PA Model

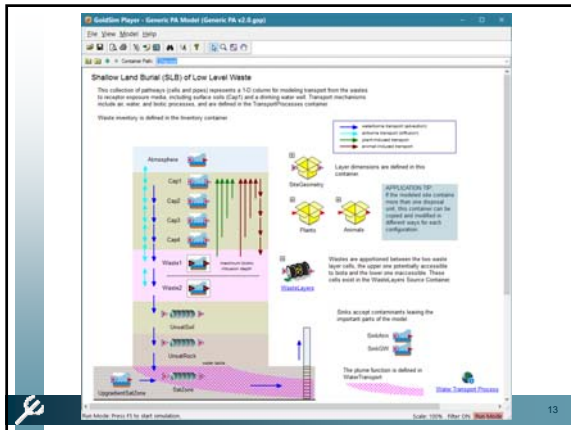
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A Generic Radiological Performance Assessment Model for a Radioactive Waste Disposal Site* (RWDS)

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Modeling elements are logically organized on the page, with clear naming and accompanying text.

Porous media Soil and Rock

Properties of the unsaturated porous medium, including porosity, bulk density, etc., are defined in SoilProperties. Soil/Water partition coefficients are in Kds. Porosity and tortuosity are defined for the air and water phases for purposes of phase-specific advective and diffusive transport.

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.

This example shows how soil/water partition coefficients ($K_{d,s}$) are defined.

Soil/water partition coefficients

A soil/water partition coefficient (Kd) is defined for each chemical element in the model (not each radionuclide Species). Units are from the original references, but GoldSim takes care of the conversions.

The following Kd values are assumed to be zero (no retardation):

Ar, Cl, I, Rn, C, H, K, Tc

The following Kd values are from Sheppard and Thibault (1990) for sand, with log-normal distributions applied as suggested in the paper:

K, Sn, Ra, U, Nb, Cs, Ac, Np, Co, Eu, Th, Pu, Sr, Pb, Pa, Am

Here's an example of how the rate of water flow into the ground is calculated.

Water advection in the unsaturated zone

Infiltration of precipitation: Surface infiltration of precipitation is represented as a simple long-term annual average infiltration rate.

Evapotranspiration: This infiltrated water is subject to evapotranspiration in the uppermost layer. This is also a long-term average rate, subtracted from the infiltration. The ET rate is correlated somewhat to the infiltration rate.

Unsaturated volumetric flow rates: Infiltrated water that does not get returned to the atmosphere flows downward into the unsaturated zone. In this case, the average velocity of the water would be simply a function of the volumetric flux and the degree of saturation of the porous medium. The value of the water advection switch is used as a multiplier to turn this process on/off.

Infiltration is defined with some uncertainty, since we do not know the value perfectly.

Water advection

Infiltration of precipitation

Evapotranspiration

Unsaturated volumetric flow rates

Statistics: Mean: 10.00 cm/yr, Std. Deviation: 3.00 cm/yr, Minimum: 0.00 cm/yr, Maximum: 20.00 cm/yr, Kurtosis: Not available

Calculator: Calc. Probability: 0.133338, Value: 10.00 cm/yr, Prob. Density: 0.133338, Cond. Tail Expectation: 12.398 cm/yr

Detail of the definition of UnsatFlux. Note that names that make sense are used.

Element ID: UnsatFlux

Description: volumetric flux of water through the unsaturated zone per

Display Units: cm/yr

Equation:
$$\text{WaterAdvection_Switch} * \max(\text{Small cm/yr}, (\text{Infiltration} - \text{Evapotranspiration}))$$

Infiltrated water that does not get returned to the atmosphere flows downward into the unsaturated zone. In this case, the average velocity of the water would be simply a function of the volumetric flux and the degree of saturation of the porous medium. The value of the water advection switch is used as a multiplier to turn this process on/off.

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:** The collection of standard GoldSim Simulation Settings is accessible through this button.

Access to results

- Total and Max Doses:** Dose results are accessed through this button, which 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: You may run the model at any time.

Browse Model: You may browse the model at any time.

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Dose Time History Results - Total and Peak Effective Dose Equivalents (EDE)

Total dose (excluding dose from Rn and progeny in air)
Average time to loss of Institutional Control: 100yr Simulation duration: 10000yr

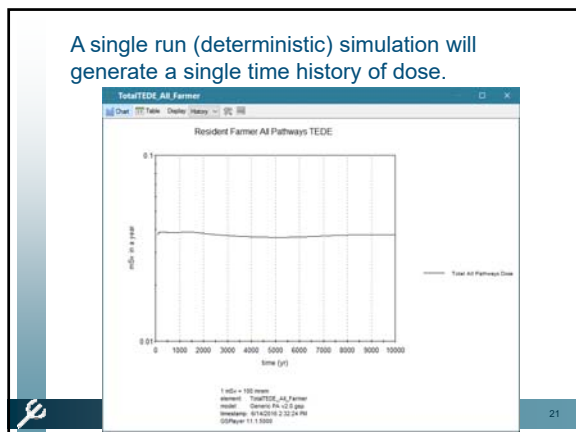
Performance objectives	Air pathway	All pathways
DOE G 435.1-19VP(1)(a,b)	0.1 mSv/yr	0.25 mSv/yr*
Resident farmer		
Mean peak dose	5.78e-5 mSv/yr	0.0387 mSv/yr
95th %ile peak dose	5.78e-5 mSv/yr	0.0387 mSv/yr
Probability of exceedence	0	0
Transient occupant		
Mean peak dose	1.42e-5 mSv/yr	0.0135 mSv/yr
95th %ile peak dose	1.42e-5 mSv/yr	0.0135 mSv/yr
Probability of exceedence	0	0

* NUREG-1573 suggests that the mean all-pathways peak dose be below 0.25 mSv/yr and that the 95th percentile of the peak dose be below 1 mSv/yr (as in the CCDFs).

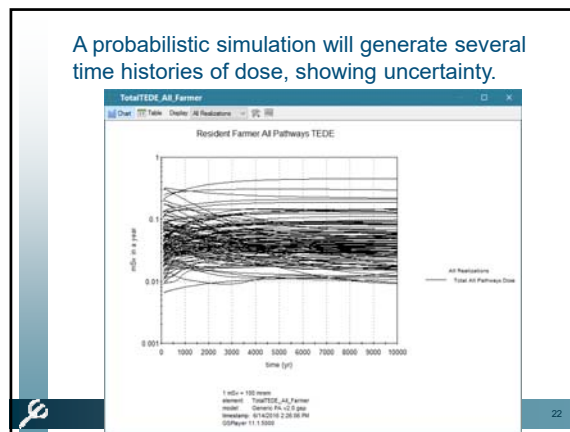
View All Results Home

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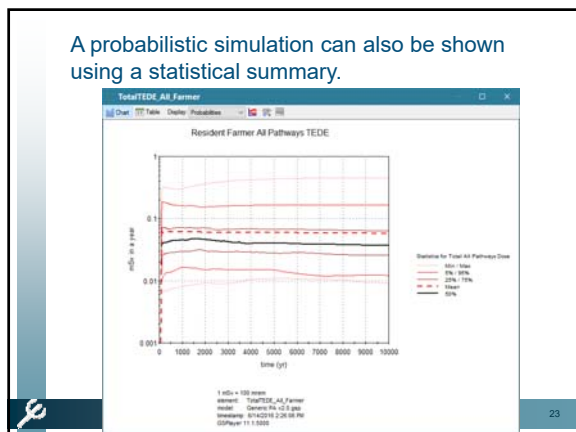
A single run (deterministic) simulation will generate a single time history of dose.



A probabilistic simulation will generate several time histories of dose, showing uncertainty.



A probabilistic simulation can also be shown using a statistical summary.



Many types of results can be examined.

Modeling results

- Sensitivity Analysis:** Result elements specifically constructed for the post-processing sensitivity analysis.
- Media Concentrations:** The concentrations of modeled species in various environmental media are collected here and are used in dose assessment.
- Flux Results:** Some interesting results are graphs of the relative influence of various processes, expressed as net fluxes by process into the CAPT cells.
- Radon Performance:** Performance Assessment requires the evaluation of the fate of radon specifically, and DOE G 435.1 offers three performance objectives for compliance.
- Receptor Choices:** Estimates of TEDE for the receptors, from calculations in the DoseAssessment container.

Result Mode Scale: 100% Filter: CH Result Mode

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**The Generic PA Model
is available here:**

www.neptuneinc.org/genericpa

**The GoldSim Player
is available here:**

www.goldsim.com/web/downloads

