GoldSim and the Depleted Uranium Performance Assessment

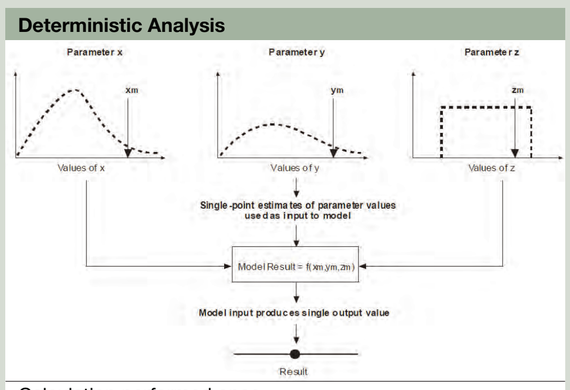
Evaluating Future Performance with Probabilistic Performance Assessment

A performance assessment (PA) is a tool that provides decision-makers with information from predictive evaluations of a complex system. These evaluations use conceptual models of the system and the processes within the system, typically including comparison of predicted behavior with established criteria. The depleted uranium (DU) PA is the set of activities needed to quantitatively analyze the behavior of the proposed DU disposal system and its components with respect to its post-closure performance.

Many of the model parameters needed to perform a PA are best represented by a range, or distribution, of values (e.g., amount of annual precipitation).

- **A Deterministic PA** selects a single value for each parameter from the possible range of values (see the diagram to the right). A deterministic PA only needs to solve the model once, because each parameter has only one value. Because each parameter's value is selected conservatively, a deterministic PA usually produces very conservative results, but it is usually unknown how conservative.

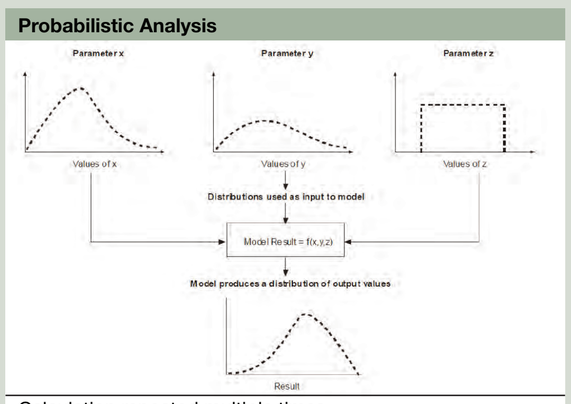
Deterministic Analysis



Calculation performed once.

- **A Probabilistic PA** first randomly selects values from each parameter's range of values, then solves the model for those values (so far identical to the deterministic PA). Then a probabilistic PA repeats the entire process using another set of randomly selected parameter values, producing another result. This process can be repeated 1,000 to 10,000 or more times, each time calculating a different result (see the diagram above). Taken together, all the results represent a distribution from which the mean (i.e., average), median (i.e., 50th percentile), or 95th percentile result can be selected. Thus, with a probabilistic PA the amount of conservatism in the result is specified.

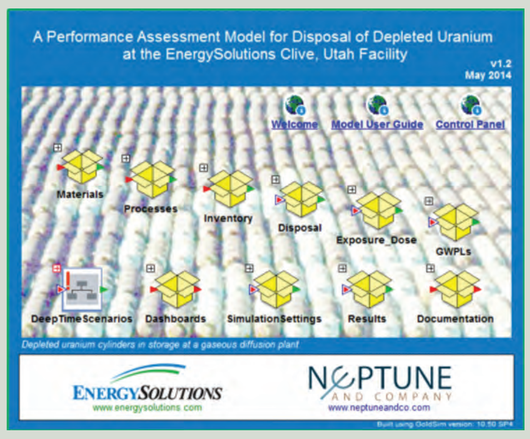
Probabilistic Analysis

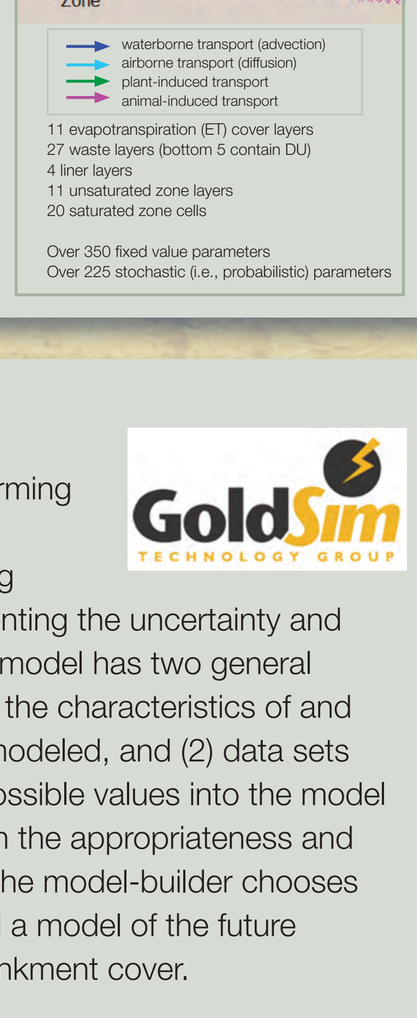


Calculation repeated multiple times.

What is the Energy*Solutions*/Neptune Clive DU PA GoldSim Model?

The Depleted Uranium Performance Assessment (DU PA) GoldSim Model is the set of equations and data that Energy*Solutions* (and its contractor, Neptune & Company, Inc.) programmed into GoldSim to model the future performance of the Federal Cell for the proposed disposal of DU. These GoldSim screenshots illustrate the cover layers, the DU waste layers, and the unsaturated and saturated zones of the ground under the DU embankment, as well as the waterborne, airborne, plant-induced, and animal-induced transport paths that make-up the DU PA GoldSim Model.





11 evapotranspiration (ET) cover layers
27 waste layers (bottom 5 contain DU)
4 liner layers
11 unsaturated zone layers
20 saturated zone cells

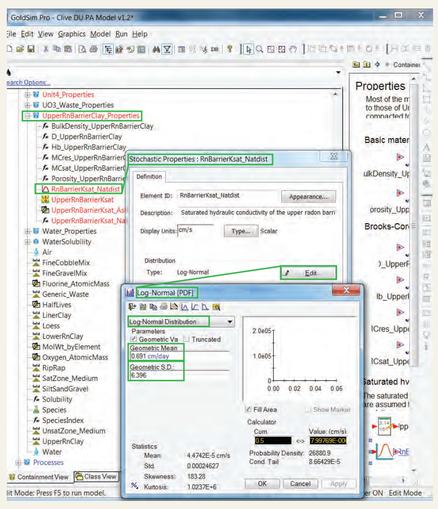
Over 350 fixed value parameters
Over 225 stochastic (i.e., probabilistic) parameters

What is GoldSim?

GoldSim is a simulation software tool for performing probabilistic performance assessment. It can support decision and risk analysis by simulating future performance while quantitatively representing the uncertainty and risks inherent in complex systems. A GoldSim model has two general components: (1) a set of equations that model the characteristics of and probable conditions affecting the thing being modeled, and (2) data sets (usually from past empirical studies) to input possible values into the model equations. A model's effectiveness depends on the appropriateness and completeness of the equations and data sets the model-builder chooses to use. Energy*Solutions* used GoldSim to build a model of the future performance of the proposed DU waste embankment cover.

Example of Building the Model's Equations in GoldSim: Stochastic Parameter Definition (Radon Barrier K_{sat})

This GoldSim screenshot is typical of what is necessary to define a stochastic (i.e., probabilistic) distribution (e.g., lognormal) and the parameters needed to define the distribution (e.g., mean and standard deviation). (A parameter is a value used in an equation that represents a physical entity.) In this example, the "naturalized" saturated hydraulic conductivity (K_{sat}) parameter for the Upper Radon Barrier of the proposed evapotranspiration cover for the DU waste embankment is defined as a lognormal distribution with a geometric mean of 0.691 centimeters per day (cm/day) and a standard deviation of 6.396. Appendix 5 of the June 2014 DU PA provides details on how Energy*Solutions* derived this parameter. Also, DU PA Safety Evaluation Report (SER), Section 4.1.1.1 discusses concerns raised by DEQ regarding this parameter.



There are similar definitions for over 225 other parameters in the DU PA GoldSim Model.

Example of a Du PA GoldSim Model Result: Tc-99 Well Concentration

Tabular

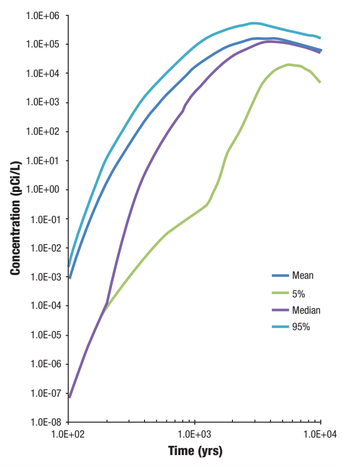
Time (yr)	Mean	S.D.	5%	Median	95%
0	0	0	0	0	0
1	0	0	0	0	0
10	2.20E-27	4.22E-26	1.25E-30	1.25E-30	1.25E-30
20	4.72E-16	6.56E-15	1.80E-19	1.80E-19	1.27E-18
30	1.47E-12	1.66E-11	4.22E-16	4.22E-16	4.54E-14
40	3.12E-10	3.01E-09	7.03E-14	7.03E-14	4.53E-11
50	1.62E-08	1.38E-07	2.91E-12	2.91E-12	7.22E-09
60	3.47E-07	2.66E-06	5.00E-11	5.00E-11	3.41E-07
70	4.03E-06	2.83E-05	4.77E-10	4.77E-10	6.91E-06
80	3.01E-05	0.000197	2.99E-09	2.99E-09	7.66E-05
90	0.000163	0.000992	1.54E-08	1.54E-08	0.00045
100	0.000681	0.003909	6.21E-08	6.21E-08	0.002014
120	0.007972	0.040121	6.42E-07	6.42E-07	0.034304

460	498.12	1157.9	0.009732	12.133	3018.8
480	623.98	1427.6	0.011696	17.118	3758.6
500	771.11	1738.1	0.013894	23.53	4617.7
520	941.37	2092.3	0.016336	31.625	5605.4
540	1136.6	2492.9	0.019026	41.674	6731

980	14609	26207	0.13941	1860.5	75651
1000	15711	27983	0.14873	2060.6	80973
1250	32859	53832	0.29376	6352.5	1.58E+05
1500	54339	82660	1.4011	13254	2.48E+05
1750	76941	1.09E+05	9.653	24531	3.29E+05
2000	97889	1.31E+05	36.348	37616	3.95E+05

8500	79222	56490	9830.2	67298	1.90E+05
8750	76018	55186	8874	64072	1.84E+05
9000	72937	53933	7967	60962	1.79E+05
9250	69977	52708	7124.4	57976	1.74E+05
9500	67136	51519	6341.2	55106	1.69E+05
9750	64409	50365	5616.4	52348	1.65E+05
10000	61794	49234	4954.4	49703	1.60E+05

Graphics



Section 4.2.2 of the DU PA SER discusses doses received by the general population due to the groundwater ingestion pathway. One of the radionuclides contributing to those concerns is technium-99 (Tc-99). This table and figure output by GoldSim show the Tc-99 groundwater concentration at a well located 90 feet from the disposal embankment over the 10,000-year Compliance Period. In the SER, these concentrations were used to calculate a dose to a member of the general population who consumes this well water (after it has been processed to reduce its salinity to potable levels).

Similar tables and figures of well water concentrations can be generated by the DU PA GoldSim Model for all other radionuclides, as well as for all other results (e.g., doses) calculated by the DU PA GoldSim Model. The SER and the June 2014 DU PA show many similar tables and figures that were generated by the GoldSim Model.