Deep Time Analysis

What is Deep Time?

Utah Administrative Code (UAC) R313-25-9(5)(a) requires a performance assessment demonstrating that the depleted uranium (DU) disposal facility will meet Utah and federal standards for the following time periods:

- *"the compliance period shall be a minimum of 10,000 years."*
- *"Additional simulations shall be performed for the period where peak dose* [of radiation] *occurs and the results shall be analyzed qualitatively."*

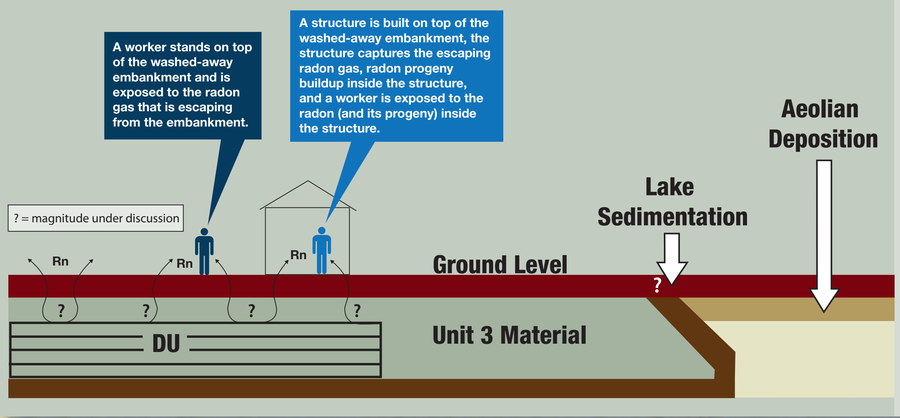
"Deep Time" = The period, after the Compliance Period, when peak dose occurs. The U.S. Nuclear Regulatory Commission (NRC) often refers to Deep Time as the "Performance Period."

DEQ's Deep Time Analysis Model

To analyze the proposed Federal Cell's performance over Deep Time, the Utah Department of Environmental Quality (DEQ) and Energy*Solutions* used similar models, but with substantially different parameters. DEQ (and its contractor, SC&A, Inc.) used the following model:

- In future, the Clive area will experience the periodic return and receding of a large lake that once covered it.
- Before the return of the first lake, the DU would be buried under the Federal Cell embankment, with little opportunity for general population exposure. During this time, aeolian deposition (i.e., dust from the air) would gradually build up the ground surface level surrounding the embankment.
- For the purpose of the Deep Time analysis, both DEQ and Energy*Solutions* assumed that the Federal Cell embankment would be washed away to the level of the surrounding land by the first returning lake to the Clive area. Sedimentation would then build up on the new lakebed.
- Without the cover of the embankment, radon gas (Rn), which is a member of the uranium-238 decay series, will have less material above it to mitigate its release into the environment.
- Two exposure pathways were evaluated for the Deep Time after the first lake recedes—shown in the image left.

After First Lake Recedes



NRC Performance Period ("Deep Time") Analysis

NRC Proposed Rule10 CFR Parts 20 and 61, "Low-Level Radioactive Waste Disposal" (Federal Register, Vol. 80, No. 58, 16091, March 26, 2015), provides guidance on what a deep time analysis should include:

- "*The metric for the performance period* [Deep Time] *analyses would be to minimize releases to the public to the extent reasonably achievable."*
- "*Considering the timeframes involved, uncertainties may be considerable and therefore the precision typically assigned to a dose limit is not warranted."*
- "*Whereas the calculated dose in a numerical model may be precise, the significance of that dose to a future generation is unknowable in the present."*
- "*Although a dose limit is not prescribed, it is recommended that doses or concentrations and fluxes of radionuclides in the environment are calculated as they are appropriate to use to compare alternatives using a common metric*."

DEQ's deep time analysis covers the same elements as the NRC's proposal.

DEQ's Deep Time Analysis Results

These tables compare the calculated outdoor and indoor radon and daughter product doses, concentrations, and fluxes from the DEQ/SC&A Deep Time Model with naturally occurring radioactivity measured in the State of Utah, Tooele County, and 84029 Zip Code; and with the U.S. Environmental Protection Agency's (EPA's) radon flux standard in Title 40 of the Code of Federal Regulations (CFR) Part 61.

Outdoor Radon Concentration and Dose

Radionuclides	Radon Flux (pCi/m²-s)	
Rn-222	20 (40 CFR)	356 (SC&A)
Outdoor Concentration (pCi/m³)		
Rn-222	9.8E+02	1.7E+04
Po-218	1.6E+02	2.8E+03
Pb-214	2.3E+00	4.0E+01
Bi-214	3.2E-02	5.8E-01
Outdoor Dose (2,000 hr/yr) (mrem/yr)		
Rn-222	1.2E+00	2.1E+01
Po-218	3.2E+00	5.7E+01
Pb-214	2.2E-01	4.0E+00
Bi-214	2.8E-03	5.0E-02
Total	4.6E+00	8.2E+01

For several different types of radium-containing facilities (but not for a DU disposal facility), the EPA has set a radon flux standard in 40 CFR Part 61 at 20 pCi/m²-s.

The DEQ/SC&A Deep Time analysis calculated a radon flux of 356 picoCuries per square meter per second (pCi/m²-s), resulting in the doses shown in the "SC&A" columns of these tables.

Inside Radon Concentration and Dose

Radionuclides	Radon Flux (pCi/m²-s)		Radon Measurement Program Results			
			State of Utah	Tooele County	Zip Code: 84029	
	20 (40 CFR)	356 (SC&A)			Average	Largest
Inside Concentration (pCi/m³)						
Rn-222	7.2E+03	1.3E+05	5.2E+03	5.7E+03	1.1E+04	9.8E+04
Po-218	6.7E+03	1.2E+05	4.8E+03	5.3E+03	1.1E+04	9.1E+04
Pb-214	4.1E+03	7.3E+04	2.9E+03	3.2E+03	6.4E+03	5.6E+04
Bi-214	2.8E+03	4.9E+04	2.0E+03	2.2E+03	4.3E+03	3.8E+04
Inside Dose (2,000 hr/yr) (rem/yr)						
Rn-222	8.5E-03	1.5E-01	6.1E-03	6.7E-03	1.3E-02	1.2E-01
Po-218	1.4E-01	2.4E+00	9.8E-02	1.1E-01	2.1E-01	1.9E+00
Pb-214	4.0E-01	7.2E+00	2.9E-01	3.2E-01	6.3E-01	5.5E+00
Bi-214	2.4E-01	4.2E+00	1.7E-01	1.9E-01	3.7E-01	3.2E+00
Total	7.8E-01	1.4E+01	5.7E-01	6.2E-01	1.2E+00	1.1E+01

The Utah DEQ Division of Radiation Control (DRC) makes available to Utah residents an indoor radon test kit that can be used to determine a home's indoor radon level. As of December 2014, the test kit results from 38,407 Utah homes have been compiled by DEQ/DRC. These results are listed in the Radon Measurement Program Results columns.

DEQ Concerns about the Energy*Solutions* Deep Time Analysis

DEQ had the following concerns about the Energy*Solutions* (ES) Deep Time analysis. The ES model:

- Selected an intermediate lake sedimentation rate that was too high and therefore a sedimentation layer that was too deep, resulting in a lower calculated radon flux.
- Did not calculate radon buildup inside a structure.
- Did not calculate buildup of radon daughter products.
- Only calculated radon flux, not the doses or concentrations that result from radon flux.