U.S. Department of Energy
Office of Environmental Management

Low-Level Waste Disposal Capacity Report, Revision 1

Appendix C. Key Radionuclides and Generation Processes

This appendix presents the criteria that was used to select the key radionuclides that were analyzed in this Report. It contains a more complete discussion of the major key radionuclides that have the greatest impact on DOE LLW disposal capacity. A discussion of the major processes that generate DOE LLW is provided, and finally, a discussion of Special Case Waste is provided.

C.1 Criteria for Selection of Radionuclides:

The following criteria were developed to select the list of radionuclides that are important to evaluation of radiological capacity at DOE LLW disposal facilities:

- Half-life in excess of 5 years.
- Identified in site documents from throughout the DOE complex as a radionuclide critical to evaluation of dose to the public through ground water, atmospheric, or inadvertent intruder scenarios.
- Daughter products of the identified radionuclides are excluded from the list. Since doses from radiologically significant daughter products are considered in the estimation of parent nuclide dose (equilibrium stage), the activity of the daughters need not be reported. Reporting bothparents and daughters can be confusing and may lead to an overestimate of the radionuclide inventory and resultant dose.
- Categories for C-14 and Ni-63 activated metal were added because the analysis of radiological capacity recognizes a lower leach rate for radionuclides within a metal matrix.
- Categories for "Uranium-Natural" and "Plutonium-Weapons" were added to facilitate user identification of nuclide profiles.

These criteria resulted in 51 nuclides being included in the 1997 Technical Data Request. (***)

C.2 Key Radionuclides

This section provides additional detail on the characteristics and sources of the radionuclides that are most important for assessing radiological impacts on Department disposal operations. (***)

C.2.4 Uranium

Natural uranium chiefly contains three isotopes of uranium—uranium-234 (^{234}U), uranium-235 (^{235}U), and uranium-238 (^{238}U). Uranium-234 is a member of the ^{238}U decay chain and usually found in equilibrium with its ^{238}U parent. The amount of ^{238}U in natural uranium is more than 99 percent, but the ^{235}U, present at 0.72 percent in natural uranium, is most radioactive and important in nuclear weapons and nuclear reactors. Enriching uranium, a process by which the percentage of ^{235}U is increased in relation to the other uranium radionuclides, makes it useful in nuclear weapons and nuclear reactors. Uranium-234 has a half-life of 2.5 x 10^5 yr and exists as 0.0057 percent of natural uranium. Uranium-230 (^{230}U) is also a member of the ^{238}U decay chain but has a short half-life of only 20.8 days.

Uranium-238 has a half-life of 4.47×10^9 years. This radionuclide decays by alpha particle emission to ^{234}Th. A series of 14 alpha and beta transitions results in the stable ^{206}Pb nuclide. Moderately high-energy alpha particles, low-energy x-rays, and low-energy beta particles are emitted during this series of transitions.

The presence of uranium can be very significant in assessing the long-term performance of a LLW disposal facility due to the quantity, radiotoxicity, and mobility of its daughter products, which include isotopes of radium and radon.

Uranium is very reactive and forms compounds with many other elements, such as the halides, oxygen, and hydrogen. The ability of soil to adsorb uranium out of the ground water depends on a number of factors, including pH and the presence or absence of complexing agents. In the presence of low pH soil conditions, uranium is very soluble and tends to remain in the ground water rather than being adsorbed by the soil.

The principal radiological hazard associated with uranium is due to the relatively high-energy alpha particles its radionuclides and daughters emit. Since these alpha particles do not penetrate materials easily, external exposure to uranium does not pose a high risk. The principal risk is due to either inhalation or ingestion. Inhalation occurs either from release of volatile uranium compound or from suspension of volatile uranium-laden aerosols. Ingestion can occur when the uranium is introduced into water for consumption or the food chain by plant uptake. When uranium is either ingested or inhaled, it is removed from the body with a biological half-life varying between 6 and 5,000 days, depending on which organ has become contaminated. Uranium tends to concentrate in the kidneys and the bones. Additionally, if inhaled, the lungs can receive a dose.