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LONG TERM UNCERTAINTY IN RADIOLOGICAL PERFORMANCE ASSESSMENTS OF LOW LEVEL WASTE FACILITIES AT SAVANNAH RIVER SITE

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ABSTRACT

Radiological performance assessments are being conducted for the Saltstone Disposal Facility and the E-Area Vaults at the Savannah River Site near Aiken, South Carolina. Saltstone is a solidified waste form which will contain very low levels of radionuclides but considerable levels of nitrate. The E-Area Vaults will contain solid, radioactively contaminated waste. Preliminary results of the assessments indicate that adequate performance will be very sensitive to the degradation scenario adopted for the cover and containment systems for these facilities.

INTRODUCTION

The U. S. Department of Energy (DOE) Order 5820.2A (DOE 1988) requires a site-specific radiological performance assessment for each DOE low-level waste (LLW) disposal facility designed and utilized subsequent to issuance of the order. The purpose of an assessment is to demonstrate compliance with performance objectives for DOE LLW management established in the order. In addition to ensuring compliance with other DOE Orders addressing radiation exposures and U. S. Environmental Protection Agency (EPA) regulations for atmospheric releases, these performance objectives include protecting groundwater resources consistent with federal, state, and local requirements.

Oak Ridge National Laboratory has been tasked with doing radiological performance assessments of the LLW Saltstone Disposal Facility (SDF) and E-Area LLW Vaults at the Savannah River Site (SRS) in a joint effort with the Idaho National Engineering Laboratory and Hanford. The most challenging aspect of these, and perhaps all, performance assessments involves predicting the long-term performance of the various engineered features of the waste-forms, containment, and closure designs over the time period for which significant quantities of radionuclides are present in the facilities. There is no specific regulatory guidance on the length of time for which potential exposure must be predicted nor on the amount of uncertainty which can be tolerated.

THE SRS LLW SALTSTONE DISPOSAL FACILITY AND E-AREA VAULTS

The SRS was acquired by the U. S. government in 1950 and covers approximately 780 sq km in southwestern South Carolina.

The site receives over 100 cm of rainfall annually and thus is classified as a humid subtropical region. As is the case with other sites in the DOE complex, waste management and environmental restoration have come to the forefront of activities at SRS in the last decade.

Both Z-Area and E-Area are on topographic highs which slope toward surrounding creeks. The historic high water table lies at a minimum of 7 m below the existing grade at Z-Area, and 6 m below the existing grade at E-Area. The groundwater under both facilities discharges largely to the local creeks, such that off-site contamination of groundwater is unlikely to be significant. A lower regional aquifer is protected from downward migration of contaminants by a thick impermeable zone. Discharge of contaminated groundwater to surface water may carry contaminants off-site, but dilution in streams provides a large amount of protection to potential water users.

The SDF handles disposal of liquid waste streams which are solidified in a cement matrix. Radionuclides of consequence in the liquid waste include H-3, Cs-137/Ba-137m, Ru-106/Rh-106, Sr-90/Y-90, Tc-99, and I-129. A slurry consisting of a high nitrate-content salt solution, Portland cement, flyash, and slag is piped into below-grade concrete vaults. Upon solidification of the resulting monolith of saltstone, the remaining headspace will be filled with clean cement, and the vaults will be protected from infiltration until final closure with various overburden layers. Nitrate is present in the saltstone product at very high concentrations (about 7 wt%) and thus is of potential concern from the standpoint of the EPA's drinking water standard of 10 mg/L for NO_3^- as N.

The E-Area Vaults will receive discarded trash, equipment, and machinery that have been contaminated by low levels of radioactivity. Tritium, C-14, Co-60, Cs-137/Ba-137m, Mn-54, Ni-63, Se-75, Sr-90/Y-90, and Zn-65 are the nuclides of potential concern. With the exception of C-14, none of these radionuclides are long-lived. Most of the nuclides will have decayed to stable isotopes by 300 years. Long-lived radioactive isotopes of uranium and transuranics are expected to be present in waste received by the E-Area Vaults only in very minor amounts. Primary containment will be in the form of metal boxes or drums for smaller items. Larger items will be placed directly into the concrete vaults along with the metal boxes and drums. A sloping concrete cover completes each vault. Separate vaults for storage of tritium and waste contaminated by C-14 are planned for this facility.

When all vaults are full at both facilities, earthen covers, designed to minimize infiltration of rainwater and

intrusion by roots or burrowing animals, will be placed over the entire facilities.

ANALYSIS

Demonstration of compliance with DOE Order 5820.2A requires that pathways to potential receptors be identified and potential exposures be predicted over an indefinite period of time. This must be done for three recognized time periods of concern: the operational time period (about 30 years for the SDF and 20 years for the E-Area Vaults), the post-closure institutional control time period (about 100 years), and the post-institutional control time period. Potential receptors fall into two categories: on-site receptors, or inadvertent intruders, and off-site receptors. During institutional control, on-site receptors are not present as the site boundaries are still maintained.

After 120 or 130 years, the possibility of excavation or drilling into the facilities by inadvertent intruders must be considered. Intact, or non-degraded, concrete vaults are fairly robust from the standpoint of external exposure to on-site receptors. The massive concrete buffer (almost 0.5-m-thick vault walls and ceilings) around the saltstone monolith and E-Area waste forms makes damage due to well drilling or excavation highly unlikely.

As stated in DOE Order 5820.2A, the SDF and E-Area Vaults must be designed to meet federal, state and local requirements for the protection of groundwater, as well as satisfy the other requirements for controlling radiation exposures. The EPA's drinking water standard (EPA 1990), which is being applied to groundwater for the purpose of evaluating compliance, limits the annual dose received from groundwater contaminated by radionuclides to 4 mrem and specifies maximum contaminant levels for various chemical compounds such as nitrate. This is the limiting requirement for LLW facilities like the SDF and E-Area Vaults if mechanical intrusion into the facility is not credible.

Over long periods of time, however, it is expected that natural processes may degrade the cover and containment systems so that infiltration into the facilities is increased and the ability of the Saltstone monolith or E-Area waste forms to withstand leaching is increasingly compromised. Erosion of ground surfaces, intrusion by burrowing animals or plant roots, and seismic events are potential sources of disruption of infiltration barriers. Cracks in the concrete vaults and the saltstone monolith may increase leaching to an unacceptable degree, and the concrete vaults may eventually crumble.

Because many of the radionuclides in the both facilities

are relatively short-lived, it is possible that they will have decayed to insignificant levels by the time natural processes have compromised the containment of the facility to any significant degree. Long-lived Iodine-129, Tc-99 and nitrate are, however, of concern for the SDF.

Much of the uncertainty in the results of individual exposure analyses as a consequence of LLW disposal lies not in the wide range in values of quantifiable parameters but in the wide range in credible scenarios describing conditions at the facilities hundreds to thousands of years into the future. There is not an official time cutoff for calculating exposures for DOE radiological performance assessments, and uncertainties become unfathomable after the first several hundred years due to poorly understood mechanisms of degradation of engineered barriers.

CONCLUSIONS

Despite the large amount of precipitation received annually by the SRS, the use of multiple barriers in disposal of LLW at two facilities at the site appears to provide both a workable solution to the common problem of subsidence in waste disposal facilities and a means of radically reducing the leachability of wastes. However, because long-lived radionuclides and non-decaying substances of concern may outlast the lifetime of engineered containment, their presence may adversely impact the performance of these facilities at some time in the future.

Degradation of engineered systems must be addressed in performance assessments. Recognizing that there is considerable uncertainty arising from the limited knowledge of degradation mechanisms and timing, there must be a concerted effort by both technical personnel involved in designing LLW facilities and policy makers and regulators to address this large uncertainty. Design of facilities should acknowledge the inevitability of degradation of protective and containment features. Policy makers and regulators must address the issue of the amount of uncertainty that will be tolerated in performance evaluations and the length of time that should be considered in assessing performance.

REFERENCES

DOE, 1988. *Radioactive Waste Management,* DOE Order 5820.2A, U. S. Department of Energy.

EPA, 1990. "National Primary Drinking Water Regulations," 40 CFR 141, U. S. Environmental Protection Agency.

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