PERFORMANCE ASSESSMENT REVIEW FOR DOE LLW DISPOSAL FACILITIES

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ABSTRACT

The United States Department of Energy (US DOE) disposes of low-level radioactive waste in near-surface disposal facilities. Safety of the disposal operations is evaluated for operational safety as well as long-term safety. Operational safety is evaluated based on the perceived level of hazard of the operation and may vary from a simple safety assessment to a safety analysis report. Long-term safety of all low-level waste disposal systems is evaluated through the conduct of a radiological performance assessment.

The US DOE has established radiological performance objectives for disposal of low-level waste. They are to protect a member of the general public from receiving over 25 mrem/y, and an inadvertent intruder into the waste from receiving over 100 mrem/y continuous exposure or 500 mrem from a single exposure. For a disposal system to be acceptable, a performance assessment must be prepared which must be technically accurate and provide reasonable assurance that these performance objectives are met. Technical quality of the performance assessments is reviewed by a panel of experts.

The panel of experts is used in two ways to assure the technical quality of performance assessment. A preliminary (generally 2 day) review by the panel is employed in the late stages of development to provide guidance on finalizing the performance assessment. The comments from this review are communicated to the personnel responsible for the performance assessment for consideration and incorporation. After finalizing the performance assessment, it is submitted for a formal review. The formal review is accomplished by a much more thorough analysis of the performance assessment over a multi-week time period. The panel then formally reports their recommendations to the US DOE waste management senior staff who make the final determination on acceptability of the performance assessment.

A number of lessons have been learned from conducting several preliminary reviews of performance assessments. These lessons are shared among the various US DOE sites to improve the process of evaluating low-level waste disposal sites for long-term performance.

INTRODUCTION

The United States Department of Energy (US DOE) manages several large sites in various locations. These sites are involved in nuclear material production and testing, nuclear reactor development and testing, and research and development. Low-level radioactive waste generated at these sites is disposed in near-surface disposal facilities located at six of the sites.

Safety of the low-level waste disposal facilities, as well as all US DOE facilities, is a primary criterion in their design and operation. Safety of low-level waste disposal facilities is evaluated from two perspectives. Operational safety is evaluated based on the perceived level of hazard of the operation. The safety evaluations vary from simple safety assessments to very complex safety analysis reports, depending on the degree of hazard associated with the facility operation.

Operational requirements for the Department's low-level waste disposal facilities, including long-term safety are contained in DOE Order 5820.2A, Radioactive Waste Management.

This paper will focus on the long-term performance analysis rather than on operational safety analysis.

PERFORMANCE OBJECTIVES FOR WASTE DISPOSAL

Requirements for management of radioactive waste are contained in DOE Order 5820.2A, Radioactive Waste Management. This newly revised Order became effective on September 26, 1988. Chapter III of the Order details policy and requirements for management of low-level waste.

Performance objectives for low-level waste management are summarized below:

1. Protect public health and safety in accordance with DOE Orders.
2. Assure that no member of the public receives more than 25 mrem per year, effective dose equivalent, from all pathways combined.
3. Assure that the committed effective dose equivalents received by inadvertent intruders will not exceed 100 mrem/yr. for continuous exposure or 500 mrem for a single acute exposure.
4. Protect ground water resources, consistent with Federal, State and local requirements.

PERFORMANCE ASSESSMENT REQUIREMENT

Chapter III also requires that low-level waste disposal facilities prepare and maintain a radiological performance assessment to demonstrate compliance with the performance objectives. The Order further requires that an Oversight and Peer Review Panel be established to ensure consistency and technical quality within the DOE complex in the development and application of performance assessment models that include site specific geohydrology and waste composition.

PERFORMANCE ASSESSMENT REVIEW PANEL

Panel members were selected by the Department's Office of Defense Waste and Transportation Management (now the Office of Waste Operations) from nominees presented by each of the Field Offices. One member was appointed by the Office of Environment, Safety and Health (EH). In addition, the Department's Office of Nuclear Energy (NE), the U. S. Nuclear Regulatory Commission (NRC) and the U. S. Environmental Protection Agency (EPA) were invited to appoint technical advisors to the Panel. The members of the panel and advisors are shown in Table I.

The process of review, as determined by the Panel, consists of two parts. First, as a performance assessment is being developed, the Panel will conduct an informal review. The informal review consists of tours and discussions at the disposal facility relative to the planned performance assessment methodology followed by recommendations from the Panel to enhance the development of the assessment. Second, when the performance assessment is finalized, the report will be submitted to the Office of Waste Operations for review by the Panel. The Panel's final review will consist of review and comment by Panel members individually, followed by a meeting of the Panel to develop a consensus on the technical adequacy of the PA; the final review process is expected to require at least three months. The Panel will then communicate its findings to the Office of Waste Operations (EM-30).

The Panel has developed and issued two documents:

- Recommended Format and Content for DOE Low-Level Waste Disposal Facility Radiological Performance Assessment Reports, DOE/LLW-81
- Performance Assessment Review Guide for DOE Low-Level Radioactive Waste Disposal Facilities, DOE/LLW-93

These documents supplement guidance provided by DOE for the preparation of performance assessments (1) and will provide assistance to the Panel in conducting reviews. The Panel has also provided guidance to the Office of Waste Operations on points of compliance for the performance objectives.

PERFORMANCE ASSESSMENT DEVELOPMENT

The development of a performance assessment for a specific low-level waste disposal facility is a multi-step process. Performance assessment is, by nature, a multi-disciplinary process. Thus, the first step is to convene a working group representing the several disciplines involved. Key disciplines include: geology, geochemistry, hydrology, computer modeling, dose assessment, radiochemistry, and low-level waste disposal facility operations.

The working group must define the facility being assessed, including disposal unit design, waste generation processes, waste form and packaging (including waste treatment), waste emplacement and stabilization, technology for final closure, expected inventory of radionuclides, and inventory of chemicals potentially affecting migration of radionuclides. The disposal facility environs must also be characterized including climate, meteorology, geology, hydrology, ecology, and human population distribution (both current and projected). Use of natural resources (both current and projected) in the environs should be described as well as potentially disruptive natural phenomena such as seismicity and volcanism. Degradation of engineered design features such as concrete vaults (2) and erosion or breaching of clay caps must be considered.

The analysis of performance should begin by formulating conceptual models representing potential *mechanisms for* release of radionuclides from the waste, transport through the environment and exposure to humans.(3,4,5) Screening calculations should be employed to define the major radionuclides, pathways and exposure scenarios for more refined analysis.

For each of the scenarios and/or pathways selected for detailed analysis, the following steps should be followed:

- Present a clear and concise description of the system being analyzed,
- Define the conceptual model developed to represent the system,
- Select a computational model to analyze the conceptual model, and justify the selection.
- Perform the necessary calculations, being careful to justify all assumptions. Site-specific data should be used wherever possible.

An analysis of the sensitivity of calculations to assumptions and selection of parameters should be performed. The propagation of uncertainty in parameters and scenarios should be assessed and the overall uncertainty in the results of analyses should be estimated. The results of analyses should be compared with the performance objectives stated above.

The final step is to interpret the results of the analyses and integrate the interpretation into the overall assessment of long-term performance.

UNIQUE ASPECTS OF DOE DISPOSAL SITES

Several of the Department of Energy low-level radioactive waste disposal sites have unique features which contribute to the complexity of performance assessment. Some of these are discussed below.

At the Hanford Site and at the Savannah River Site, concrete vault technology is being used to contain cemented low-level radioactive liquid wastes. The massive concrete vaults are as large as 183 meters long, 30.5 meters wide and 7.6 meters deep. Because the disposal vaults will be covered with earth and a low-permeability cap, migration of contaminants is controlled by diffusion from the concrete waste form through the vault structure. Assessment of migration through microcracks that will form in the concrete vault walls is required. Also an assessment of the longevity of the concrete structure and the rate of change of such parameters as diffusivity and permeability is required.

At the Idaho National Engineering Laboratory, there is the potential for flooding of the disposal facility due to unusual surface water flow. Unusual accumulations of snow and subsequent rapid melting can result in surface flooding in the vicinity of the low-level waste disposal facility. Engineered features (berms) have been emplaced to mitigate this potential in the near term. The performance assessment must attempt to predict the long-term performance of the berms and the consequences of berm failure. Also, at the Idaho Site, there is the potential for a nearby volcano to become active.

At the Nevada Test Site, normal precipitation is so low (approximately 0.1 meter per year) and evaporation so high

(approximately 3 meters per year) that there may be no recharge of the groundwater in the vicinity of the disposal facility. The water table (zone of saturation) lies at a depth of about 275 meters below the disposal facility. Thus, migration of contaminants to groundwater may not be a significant pathway. Diffusion of contaminants to the ground surface and vapor phase migration of specific contaminants such as tritium may be more significant.

At the Los Alamos National Laboratory, the low-level waste disposal facility is situated on a mesa. Waste disposal units are within a few tens of meters of the steeply sloping sides of the mesa. Thus, a potential mechanism for exposure of contaminants is the lateral migration through the unsaturated zone in combination with erosion of the mesa sides (called "cliff retreat").

LESSONS LEARNED FROM REVIEWS

To date, the Panel has conducted five preliminary reviews at the Hanford site (Grout facility), at the Nevada Test Site (Area 5 burial ground), at the Idaho National Engineering Laboratory (Radioactive Waste Management Complex burial ground), at the Los Alamos National Laboratory (Area G burial ground), and at the Oak Ridge National Laboratory (Solid Waste Storage Area 6 burial ground). The Panel has also concluded the final review of the Hanford Grout facility assessment. The recommendations generated by the Panel from these reviews have been compiled and condensed into the following guidance.

- In the description of the facility and environs, sufficient detail must be presented to demonstrate adequate understanding of the facility and environmental processes potentially affecting contaminant migration. Most DOE Sites have a considerable history of environmental investigations/studies that should be factored into the performance assessment.
- Justification of each aspect of the assessment is critical. The review process is primarily that of validating the judgement of the assessor as pathways and scenarios are defined, computer codes are selected, etc. Thus, clearly stated and justified assumptions, selections of parameter values, choice of radionuclides for analysis, etc. are necessary.
- Disposal of low-level waste is evolving toward the reliance on engineered barriers to achieve performance objectives. Thus, the estimation of the lifetime of the barriers under disposal conditions is necessary for a credible performance assessment. Undue conservatism will result from taking no credit for engineered barriers.
- It may be helpful to present two overall analyses of performance, one health-conservative and the other a best engineering estimate. Such a presentation may point out critical uncertainties in the analysis and qualitatively indicate the degree of conservatism in the health-conservative analysis.
- Formulation of intruder scenarios should consider site-specific conditions (climate, environment, historical patterns of human activity, etc.) as well as "standard" scenarios (5). Passive controls (markers, land use records, etc.) may be considered in the analysis of intrusion, however, the duration and effectiveness of the controls must be justified.
- The integration and interpretation of the results of the analyses required for a performance assessment is critical to the success of the assessment. This step involves interpreting the results of several analyses in light of the associated uncertainty and sensitivity, the extent of assumptions necessary to conduct the analyses, etc. Frequently, this step is neglected or not given sufficient emphasis, resulting in diminished credibility of the assessment.
- Sufficient detail must be documented to enable the review panel to undertake confirmatory calculations in order to judge the acceptability of the assessment.

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