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CONF-920466--17

PNL-SA-20592

PERFORMANCE ASSESSMENT FOR LOW-LEVEL RADIOACTIVE WASTE MANAGEMENT AND DISPOSAL AT DOE FACILITIES REQUIREMENTS, REVIEW PROCESS, AND LESSONS LEARNED

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April 1992

Presented at the
Waste Management and
Environmental Restoration
April 9-11, 1992
San Juan, Puerto Rico

Prepared for
the U.S. Department of Energy
under Contract DE-AC06-76RLO 1830

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Richland, Washington 99352

PERFORMANCE ASSESSMENT FOR LOW-LEVEL RADIOACTIVE WASTE MANAGEMENT AND DISPOSAL AT DOE FACILITIES: REQUIREMENTS, REVIEW PROCESS, AND LESSONS LEARNED

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BACKGROUND

Department of Energy (DOE) facilities, located at sites across the nation, generate large quantities and a wide variety of low-level radioactive waste (LLRW) from nuclear defense production and research and development activities. All DOE-generated LLRW is disposed of at DOE disposal sites. Most DOE waste generating sites do not have disposal facilities on site and so must ship their LLRW to one of six currently active DOE disposal locations. Four disposal sites are located in generally arid regions: the Hanford Reservation (HANF) in the state of Washington, the Nevada Test Site (NTS), the Idaho National Engineering Laboratory (INEL), and the Los Alamos National Laboratory (LANL) in New Mexico. The other two disposal sites are located in the humid southeast: the Savannah River Plant (SRP) in South Carolina and the Oak Ridge National Laboratory (ORNL) in Tennessee.

DOE ORDER 5820.2A

Historically, the DOE has operated in a self-regulatory mode within criteria established by internal DOE directives. In 1986, DOE launched an effort to revise its internal Order on radioactive waste management activities. The objective of the revision was to make the Order more prescriptive and detailed, in response to criticisms that the existing Order was too general and did not support a system- wide management approach. The new directive, DOE Order 5820.2A, issued in September 1988 mandates requirements in chapters that address high-level waste, transuranic waste, low-level waste, naturally occurring or accelerator produced radioactive material, and decommissioning of radioactively contaminated facilities.

PERFORMANCE OBJECTIVES

Chapter III of the Order, "Management of Low-Level Waste," establishes policies, guidelines, and minimum requirements for managing the Department's LLRW. Section 3a of Chapter III defines performance objectives that DOE sites

with LLRW disposal facilities must meet to protect public health and safety. The performance objectives are summarized as follows:

- protect public health and safety in accordance with DOE Orders
- assure that no member of the public receives an annual dose above 25 mrem, effective dose equivalent, from all pathways combined. Releases of radioactivity to the general environment shall be maintained as low as reasonably achievable (ALARA). Releases to the atmosphere shall meet the requirements of 40 CFR 61
- assure that after loss of active institutional control, the committed effective dose equivalent received by the inadvertent intruder will not exceed 100 mrem/yr for continuous exposure or 500 mrem for a single acute exposure
- protect ground-water resources consistent with Federal, State, and local requirements.

The performance objectives reflect both operational and long-term requirements for the management of LLRW. It should be noted that the performance objectives apply only to waste disposal after the effective date of the Order, even if that waste is disposed in a facility which has received waste prior to the issuance of the Order. In addition, the performance objectives apply to each LLRW disposal facility located on sites having more than one such facility.

PERFORMANCE ASSESSMENT

Chapter III, Section 3b requires that each site with LLRW disposal facilities prepare and maintain a radiological performance assessment (PA) to demonstrate compliance with the radiological performance objectives. The PA provides a technical analysis of the long-term behavior of the disposal facility and its potential impacts on man and the environment. The analysis provides a basis for decisions concerning system design, acceptable waste loadings, and regulatory compliance.

Unusual site features and disposal technologies, unique hydrogeologic and climatologic regimes, and a broad variety of radioactive wastes generated within the DOE complex all contribute to the complexity of developing a PA for a DOE disposal facility. One example of an unusual site feature is the engineered surface structures (berms) at INEL which have been designed to prevent flooding at the disposal facility due to rapid snow melts; another is the steep sloping sides of the mesa on which the LANL disposal facility is located. The respective PAs would have to address the long-term consequences of berm failure, erosion of the sides of the mesa, and contaminant migration through the sides of the mesa.

Massive concrete vaults at the Hanford and Savannah River sites containing cemented radioactive liquid wastes provide examples of unusual disposal technology. These concrete vaults are as large as 183 m long, 31 m wide, and

8 m deep. Changes in the concrete's physical parameters over time and migration of contaminants through microcracks in the vault walls are some of the phenomena which must be addressed in the PA.

At NTS, the deep water table (275 m), high evapotranspiration rate, and very little precipitation, provide an example of a unique hydrogeologic and climatologic regime. In this regime, diffusion of contaminants to the soil surface and vapor phase migration of specific contaminants would have to be considered in the PA.

Given the complexity of the analysis, the development of the PA requires the participation of a multi-disciplinary team. Key disciplines include computer science, civil engineering, geology, geochemistry, health physics, hydrology, and waste management and disposal facilities operations.

PERFORMANCE ASSESSMENT PEER REVIEW PANEL

Chapter III of the Order also calls for the creation of an Oversight and Peer Review Panel of technical specialists to assure consistency, technical quality, and defensibility in the development of a site radiological PA. The Peer Review Panel (PRP), established in 1988, is comprised of eight members, one each from the six field offices with a major LLRW disposal site, one representing the waste generators, and one representing DOE Headquarters' (DOE-HQ) Office of Environment, Safety, and Health. In addition, the Department's Office of Nuclear Energy, the U.S. Environmental Protection Agency, and the U.S. Nuclear Regulatory Commission each have a technical adviser to the Panel. Members of the Peer Review Panel are listed in Table 1.

PERFORMANCE ASSESSMENT REVIEW

The Panel has established a two-stage process for reviewing each PA. The first stage is an informal, preliminary review conducted while the PA is still under development. At that time, the development of the PA should be far enough into the assessment process so that the technical direction is apparent but early enough so that the Panel's input can be efficiently accommodated in the final document. The preliminary review will focus on the overall technical approach, assumptions, rationale, justifications, conceptual models and scenarios, selected computer codes, and preliminary findings. This stage of the review includes a visit to the disposal facility, presentations by and technical discussions with facility staff, and recommendations by the Panel for enhancing the development of the PA.

The second stage of the Panel's review process is more structured and formal. The draft final PA document is submitted to the Panel for final review through the DOE Field Office and DOE-HQ. The Panel first conducts a completeness review and, if needed, issues a request for additional information to the preparers of the PA. The Panel's final review consists of detailed technical review and comments by Panel members individually, followed by a one- or two-day PRP meeting to develop a consensus on the technical adequacy of the PA. The Panel then issues formal judgement to DOE-HQ as to the technical acceptability of the PA. Three forms of judgement are possible:

- acceptable with suggestions for future improvement
- conditionally acceptable with satisfactory treatment of the technical inadequacies demonstrated to the Panel before approval
- unacceptable based on technical inadequacies.

The final review process is expected to require at least three months. The results of the Panel's review will be used by DOE-HQ in determining facility compliance with the requirements of DOE Order 5820.2A.

GUIDANCE DOCUMENTS

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, April 1989.
- *Performance Assessment Review Guide for DOE Low-Level Radioactive Waste Disposal Facilities*, DOE/LLW-93, October 1991.

The intent of these documents is to help DOE sites prepare PAs which meet the Panel's expectations in terms of content, detail, quality, and consistency.

Additional publications recommended for use in preparing PAs are provided in the reference sections of these documents.

TOPICS ADDRESSED IN THE PERFORMANCE ASSESSMENT

Technical issues which should be addressed in the PA are briefly summarized below (greater detail may be found in the documents referenced above):

- Disposal facility description
  - Site characteristics
  - Waste generation process
  - Waste characteristics
- Analysis of performance
  - Source terms
  - Transport/pathways/scenarios
  - Assumptions/methodologies
- Results of analysis
  - Dose to public and intruder
  - Sensitivity and uncertainty analysis
- Quality assurance/quality control.

The PA should focus on those site characteristics that dominate the analyses. Others should be discussed in less detail. Site characteristics generally include, but are not limited to, hydrogeology, ecology and biotic conditions, natural resources, land and water use, geography and demography, climate and meteorology, geology, seismology, and natural radiation background.

For example, the hydrogeology discussion should address the ground-water and surface-water regimes, including the saturated and unsaturated zones, the presence and types of aquifers, recharge and discharge points, geologic, and geochemical and other factors controlling subsurface radionuclide transport. The description of surface-water flow should include ground-water outcropping, potential flooding, surface runoff and erosion, pathways to streams and lakes, and transfer of radionuclides to the surface.

The discussion of waste characteristics should include radionuclide type, volume, concentration, chemical and physical form, and waste packaging. Waste acceptance criteria and waste certification programs, as required by Chapter III of the Order, should also be addressed.

Source term development for all waste streams should be clearly explained. The screening process for significant radionuclides should be clearly discussed and their selection justified. Radionuclide selection may be scenario dependent.

Transport/pathway/scenario development uses mainly site-specific data and site description to identify potential release and transport mechanisms, and likely pathways of exposure to offsite receptors. An example scenario might include contaminant leaching from the concrete vault (release), moving through the soil into the saturated zone (media), flowing down-gradient in the aquifer (transport), and reaching an offsite water well (receptor) used for human consumption (exposure pathway). Inadvertent intruder scenarios must also be considered. Example intruder scenarios include agriculture, construction, and drilling. Additional scenarios that might be considered include severe storms, flooding, wind erosion, and earthquakes. A typical PA includes several scenarios. Selections of scenarios should be justified.

The assumptions/methodologies section should include a discussion of the rationale behind the selection of computer modeling codes, their capabilities and limitations. Verification, calibration, and validation of these codes should be addressed. In a typical PA, a large number of assumptions are necessary to satisfy input parameters of the various codes, to simplify calculations, or to compensate for the lack of site-specific data. In all instances, the assumptions made should be justified.

Results of analysis should be summarized, integrated, and usually presented as a function of time. Interpretation of results should include a discussion of sensitivity to various parameters and assumptions, an analysis of uncertainty resulting from assumptions made, and limitations in the available data.

Projected doses to members of the public and the intruder should be presented for each scenario, pathway, and significant radionuclide. Summaries of results and analyses should provide comparisons with the performance objectives.

The use of quality assurance/quality control (QA/QC) is essential in the preparation of the PA. Work should be conducted under a written QA/QC program in accordance with the requirements of American Standards Institute/American Society of Mechanical Engineers Nuclear Quality Assurance-1 and other appropriate standards.

LESSONS LEARNED

To date, the Panel has conducted preliminary reviews for the following facilities: the Grout Facility at the Hanford Site, Area 5 burial ground at the Nevada Test Site, Area G burial ground at the Los Alamos National Laboratory, the Solid Waste Storage Area 6 at the Oak Ridge National Laboratory, and the Radioactive Waste Management Complex at the Idaho National Engineering Laboratory. The Panel has also concluded a final review of the Hanford Grout Facility.

A number of general as well as site-specific recommendations have evolved from the Panel's reviews. Some of the more general recommendations are summarized below:

- Present sufficient details about the site and its environs which demonstrate a clear understanding of the processes affecting the performance of the disposal facility.
- Support all estimates of the behavior, longevity and effectiveness of any engineered barriers under disposal conditions.
- Describe and justify all components of an exposure scenario. Scenarios should be consistent with site-specific conditions.
- Explain and justify each aspect of the assessment. Clearly state and justify assumptions, selected parameter values, radionuclides, pathways, choice of codes, etc.
- Present sufficient details to enable the review panel to confirm calculations.
- Summarize, integrate and interpret the results of the analyses. Include an overall assessment of facility performance.

SUMMARY

DOE Order 5820.2A requires a radiological performance assessment (PA) for analyzing the long-term behavior of DOE LLRW disposal operations and the potential impacts on man and the environment. The Order also mandates an Oversight and Peer Review Panel to ensure consistency and technical quality in the development of a site PA. The development of the PA is an interactive and

iterative process which provides a basis for decisions concerning system design and acceptable waste loadings. The findings and recommendations by the Panel are used by DOE-HQ to make a final determination on the acceptability of the PA. To date, the Panel has issued guidance documents for preparing a PA and has conducted five preliminary and one final review of site PAs. Lessons learned from the Panel's reviews provide valuable guidance for future preparation and refinement of the site PAs.

Table 1

PEER REVIEW PANEL MEMBERS

Member	Affiliation	DOE Field Office
Robert L. Dodge	Reynolds Electric Nevada Test Site	Nevada
Wayne R. Hansen	LANL	Albuquerque
William E. Kennedy, Jr.	Battelle-PNL	Richland
David W. Layton	LLNL	San Francisco
Donald W. Lee	ORNL	Oak Ridge
Steven J. Maheras	EG&G Idaho INEL	Idaho
Stanley M. Neuder	Battelle-PNL Washington, DC Office	DOE-HQ Office of Environment, Safety & Health; Environmental Guidance Division
Elmer L. Wilhite (Chairman)	Westinghouse Savannah River Co. Savannah River Site	Savannah River

The information contained in this paper was developed during the course of work for the U.S. Department of Energy under Contract No. DE-AC06-76RLO 1830.

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DATE
FILMED
7/9/93