LOW-LEVEL RADIOACTIVE WASTE PERFORMANCE ASSESSMENT TECHNICAL ISSUES AND BRANCH TECHNICAL POSITION

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ABSTRACT

The U.S. Nuclear Regulatory Commission (NRC) is developing a Branch Technical Position (BTP) on Performance Assessment of Low-Level Radioactive Waste (LLW PA) Disposal Facilities. The purpose of the BTP is to provide license applicants, licensees, Agreement States, and NRC staff with an acceptable approach for conducting and evaluating LLW PA's of disposal facilities. The BTP defines LLW PA in the context of 10 CFR Part 61 requirements. The BTP also will provide a strategy for conducting PA's that provides the regulatory decision maker with a means of determining if there is reasonable assurance that a proposed disposal facility will meet the performance objectives in 10 CFR Part 61.

INTRODUCTION

The NRC is developing a Draft Branch Technical Position (BTP) on Performance Assessment (PA) of Low-Level Radioactive Waste (LLW) Disposal Facilities. The Draft BTP will address important issues in PA modeling and provide a framework and technical basis for conducting and evaluating PA's, to provide reasonable assurance that a proposed facility will meet the performance objectives in the Code of Federal Regulations, Title 10, Chapter 1, Part 61 (10 CFR Part 61) (1). The BTP will augment the guidance on review procedures contained in NUREG-1200, "Standard Review Plan for the Review of a License Application for a Low-Level Radioactive Waste Disposal Facility," Chapter 6, "Safety Assessment" (2). The Draft BTP also will provide specific guidance on using the performance assessment methodology (PAM), developed by Sandia National Laboratory for the NRC (3).

The principal guidance objective of the BTP is to provide the applicant with an acceptable methodology for performing technical analyses required in 10 CFR Part 61.13 to demonstrate compliance with the performance objectives in 10 CFR Part 61.41. This guidance is not a regulatory requirement and acceptable demonstrations of compliance may be developed by other methods. It will, however, describe an acceptable approach that would be used by the staff in evaluating a PA. The BTP will achieve the following objectives:

1. define low-level waste performance assessment (LLWPA) in the context of the 10 CFR Part 61 regulatory requirements pertaining to LLW facility performance;
2. describe an over all strategy for developing confidence in PA models used as the basis for making regulatory decisions about future performance of a LLW facility;
3. address important technical policy issues concerning interpretation and implementation of 10 CFR Part 61 technical requirements affecting how LLWPA's are conducted and evaluated; and
4. provide guidance on acceptable modeling approaches for addressing technical issues (uncertainties) about processes controlling LLW facility performance.

This paper will address the first two areas above in some detail and provide an overview of the last two.

NEED FOR PERFORMANCE ASSESSMENT GUIDANCE

The background and technical basis for developing PA guidance derives from several sources including: (1) experience of the states in establishing and regulating new LLW disposal facilities; (2) development of the PAM; (3) test case PA analyses being conducted by NRC; and (4) past and ongoing research addressing PA issues.

NRC documents that currently provide some guidance about LLWPA related issues include: the Standard Format and Content Guide, NUREG-1199 (4); the Standard Review Plan, NUREG-1200 (2); and the Environmental Standard Review Plan, NUREG-1300 (5). NUREG-1200 provides guidance applicable to evaluating a PA and presents the process that would be used by NRC staff in reviewing a license application. NUREG-1199 details the necessary components of a license application for a LLW disposal facility required under 10 CFR Part 61. In both documents, Chapter 6, "Safety Assessment," deals with the technical analyses required to demonstrate compliance with 10 CFR Part 61 performance objectives. Section 6.1, "Release of Radioactivity" (6.1.1 - 6.1.5.4) specifically deals with meeting 10 CFR 61.41 and is primarily concerned with PA. However, it provides only general guidance on LLWPA and does not address many specific issues or recommend means for resolving them.

Information necessary for meeting the 10 CFR Part 61 siting requirements are stipulated in Chapter 2, "Site Characteristics" and facility design requirements are stipulated in Chapter 3, "Design and Construction."(both NUREG-1199 and NUREG-1200). However, not all the required site characteristics data in Chapter 2 would necessarily be used in a PA. In addition, as the iterative PA is carried out, additional site data may be required that is not delineated in this chapter. Moreover, only those aspects of the facility design that are being credited in the PA or that may have an adverse impact on site performance need to be considered in the PA.

In 1991, the National Low-Level Waste Management Program (NLLWMP) assessed the status of each of the host States in their efforts to establish a LLW disposal site (6). The NLLWMP identified several areas where further guidance for PA was required by the States including:

1. an overall understanding of the performance assessment process;
2. the relationship between site characterization and performance assessment data collection;

3. modeling of infiltration rates, source term releases and concrete degradation;
4. transport of radionuclides in the environment;
5. verification and validation of computer models;
6. the use of generic data in performance assessment; and
7. uncertainty and sensitivity analyses.

DEFINITION OF PERFORMANCE ASSESSMENT

Performance assessment (PA) is defined as the technical analysis used to demonstrate compliance with the performance objectives contained in 10 CFR Part 61.41. PA is concerned with analyses of the long-term performance of a LLW facility and is not intended to address all of the issues that may arise in developing a complete safety analysis report (SAR) required for a LLW disposal facility license application (as set forth in NUREG-1199). PA, therefore, is not usually intended to address radiation safety issues related to demonstrating compliance with 10 CFR Part 61 performance objectives governing protection of individuals during operations (10 CFR Part 61.43), and stability of the disposal site after closure (10 CFR Part 61.44). For example, operational performance objectives and technical analyses required to meet them are not dealt with in PA, unless particular aspects of the facility operations will have an impact on the long-term performance of the facility. Similarly, issues relating to site characterization, and the design and construction of a facility are not discussed except insofar as they relate to assessing the post closure performance of the site and facility.

The specific technical analyses required to demonstrate compliance with 10 CFR 61.41 are contained in 10 CFR 61.13(a), which enumerates three requirements:

1. that "pathways analyzed to demonstrate protection of the general population from releases of radioactivity must include air, soil, groundwater, surface water, plant uptake and exhumation by burrowing animals;"
2. that "the analyses must clearly identify and differentiate between the roles performed by the natural disposal site characteristics and design features;" and
3. that "the analyses must clearly demonstrate that there is reasonable assurance that the exposure to humans from the release of radioactivity will not exceed the limits set forth in 10 CFR Part 61.41."

Analyses for the protection of individuals from inadvertent intrusion, as required by 10 CFR Part 61.13(b), "must include demonstration that there is reasonable assurance the waste classification and segregation requirements will be met and that adequate barriers to inadvertent intrusion will be provided." Thus specific intruder scenario analyses are not normally required in a PA. However, such an analysis may be required if the waste proposed for disposal is fundamentally different from that used in the technical analyses done for the Draft Environmental Impact Statement for 10 CFR Part 61, NUREG-0782 (6). For example, an intruder analysis might be required if a projected "waste spectrum" includes sufficiently large quantities of long-lived radionuclides such that the intruder can not reasonably be protected by the waste classification and intruder barrier requirements of 10 CFR Part 61.

Analysis of disposal site stability after closure, as required by 10 CFR Part 61.13(d) to demonstrate compliance with 10 CFR Part 61.44, is related to PA to the degree that siting, design, construction, and waste form and emplacement could influence radionuclide releases off-site. These types of analyses, however, are dealt with in the site characterization, facility design and construction sections of the regulations and the SAR. In so far as the long-term stability of the site will affect the PA analyses that demonstrate protection of the general population, the PA modeling may need to account for facility features designed to enhance long-term site performance. Paragraph 10 CFR Part 61.50 (a)(2) states that "the disposal site shall be capable of being characterized, modeled, analyzed, and monitored." The specific intent of this requirement is to provide criterion for site suitability and is aimed at minimizing the complexity of the site and the associated uncertainty in the technical analyses. The complete PA analysis, including sensitivity and uncertainty analyses, helps demonstrate compliance with this requirement.

STRATEGY FOR PERFORMANCE ASSESSMENT

The NRC formulated a PA methodology in 1987, that promotes a modular approach to LLW facility systems modeling (8). The goal is to quantify the potential release and transport of radionuclides through significant environmental pathways. The PAM embodies a generalized conceptual model of a LLW disposal facility and environs for doing PA analyses (3,9). The PAM is broken into individual sub-modeling components including: a) infiltration; b) source term; c) engineered barriers; d) transport via ground water, surface water, and air; and e) dose. The modular approach allows a mix of both complex and simple models to be used in the overall PA. The appropriate degree of modeling complexity within a module is determined by the availability of suitable data and its associated uncertainty.

The BTP describes a process of building confidence in PA models for making regulatory decisions. The PA strategy addresses the relationship between site characterization data collection and PA modeling, and explains how conservative and simple models can be used to capture model uncertainty.

In developing a PA strategy a number of desirable attributes and goals have been considered. The strategy should incorporate an iterative process that starts with relatively simple conservative models using both generic as well as some site information and become more facility and site specific as required to demonstrate compliance with 10 CFR Part 61 or to rule out a site. Where generic data is retained in the final PA iteration, it should clearly be demonstrated that it bounds actual site characteristics. The PA strategy should be comprehensive and quantitative to the extent practicable. The PA process should be integrated with site characterization and design activities, so that information necessary for demonstrating compliance with 10 CFR Part 61.41 performance objectives are developed in the initial stages of the process and are intrinsic to it. The strategy should provide a process for making a regulatory decision (i.e., there should be a clear endpoint to the process and the strategy should provide criteria for determining when that endpoint has been reached). It should incorporate a procedure for documenting the process. The strategy should incorporate a formal treatment of uncertainty as an intrinsic part of the PA decision making process, to build confidence that there is reasonable assurance that the facility will meet the performance objectives.

An overview of the proposed approach is presented in Fig. 1 and discussed below.

1. The preliminary (or screening) assessment is used in site characterization and facility design activities for

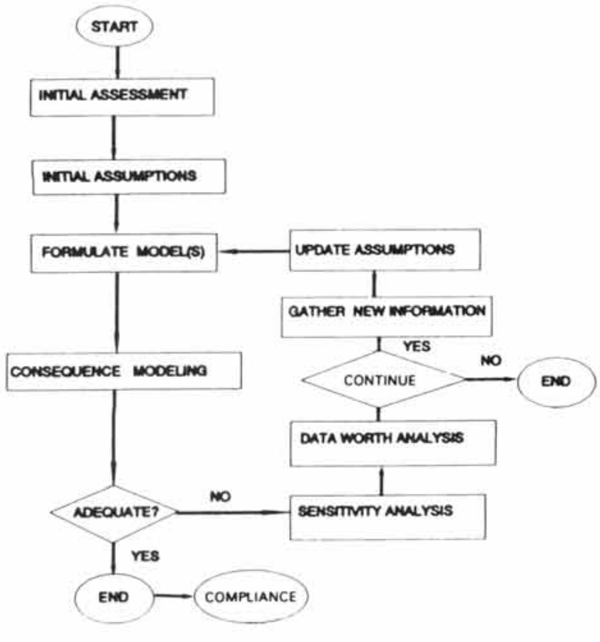

Fig. 1. Flow Chart of low-level waste performance assessment strategy.

the express purpose of evaluating existing information and directing data collection efforts towards information necessary to demonstrate compliance. The screening assessment would include broad ranges for parameters based upon existing knowledge of the site and generic information.

2. Subsequent to developing the site characterization data base and facility design, specific conceptual models with appropriate assumptions are developed. The conservatism of models, for the PA analysis, would be in proportion to data availability and would account for sources of uncertainty. This stage of the PA process would focus on developing data and parameter distributions (including correlations) for each conceptual model. This process could be participatory in nature, allowing different conceptual models of the site and facility performance to be developed.
3. The next step is to devise mathematical representations of the conceptual models and assumptions. Within this strategy, the choice of models should drive the selection of computer codes that adequately represent and implement the model, not visa-versa. The goal of having multiple conceptual models is to represent the uncertainty structure of the overall disposal system.
4. The goal of consequence analysis is to propagate parameter uncertainty and (if defensible) propagate correlations through the mathematical models to produce a distribution of doses. A number of different approaches can be used for conducting such an analysis, (e.g., Monte Carlo analysis) (10).
5. This step involves the evaluation of results and determination of their adequacy. This would include evaluating the relative conservatism among models and parameter sets and the degree of confidence that the results truly bound the performance of the system (if the analysis indicates the system will meet the performance objectives). If the system does not meet the performance objective or if there is too large an uncertainty, the analyst must determine if more data will reduce the uncertainty or if decreasing the conservatism of the model(s) is warranted.
6. The purpose of sensitivity analysis is to identify the most significant assumptions and parameters that contribute to a model exceeding the performance objectives. The goal is to focus additional site characterization work on the most important areas, thus optimizing efforts. It also is important, from a regulatory standpoint, to recognize which parameters are not significant in making a decision. This analysis is accomplished using correlation techniques on the consequence analysis results.
7. Data worth analysis is fundamentally concerned with determining which data reduce regulatory uncertainty with optimum resource expenditures. This is primarily a concern to the developer, who must determine if the additional cost of developing more information is likely to be sufficient for demonstrating compliance.
8. The specific focus for developing new information is on data used to reduce regulatory uncertainty - not just to "know" the site better. The process involves revisiting site characterization and facility design considerations, complementary modeling studies (e.g., geochemical modeling to support the use of chemically engineered backfill), and, if necessary, developing inventory limits.
9. The next step is to update assumptions and conceptual models and begin the next iteration of the PA process. Logically this would involve reducing the conservatism of the model(s) through more realistic assumptions, which necessarily will entail more detailed justification. A valid reason for reducing conservatism must be invoked to demonstrate via data that an initial assumption was overly conservative.

TECHNICAL ISSUES

The individual sub-model sections of the Draft BTP discuss issues particular to each area and develop positions and strategies for resolving them. Infiltration presents a general strategy for evaluating moisture movement through complex cover designs and recommends approaches for an infiltration evaluation methodology. The Engineered Systems section deals with the role of engineering judgement and degree of conservatism, predicting long-term performance of materials and engineered elements, and field verification issues. Source Term deals with waste categorization (waste class, waste streams, and waste forms), screening methodologies, chemical considerations, and approaches for calculating releases of radionuclides. Groundwater Transport deals with approaches to flow and transport analyses, various issues related to data, parameters, and model complexity, assessing uncertainties, model validation and credibility. Surface Water Transport provides an approach to modeling and integration with other sub-modeling analyses, and discusses a range of specific issues including uncertainties in surface water simulations. Air Transport provides a conservative approach to modeling. Dose Modeling discusses dosimetry, intake pathways, dose assessment codes, and linkage to other sub-model areas.

SUMMARY

In summary the NRC is developing a BTP for LLW performance assessment that will address a number of important issues is PA modeling. The BTP will define low-level waste performance assessment in the context of the 10 CFR Part 61 regulatory requirements for facility performance. The BTP will also describe an over all strategy for developing PA models used to demonstrate reasonable assurance that a proposed LLW disposal facility will meet the 10 CFR Part 61 performance objectives.

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