

September 18, 2001

The Honorable Richard A. Meserve  
Chairman  
U.S. Nuclear Regulatory Commission  
Washington, DC 20555-0001

Dear Chairman Meserve:

SUBJECT: TOTAL SYSTEM PERFORMANCE ASSESSMENT-SITE RECOMMENDATION  
(TSPA-SR)

This letter documents the findings of the Advisory Committee on Nuclear Waste's (ACNW's) vertical slice review of the TSPA-SR. The Department of Energy's (DOE's) Supplemental Science and Performance Analysis (SSPA) Report following the TSPA-SR, addressed a number of the issues that the Committee identified in its vertical slice review. Because our vertical slice review of the TSPA-SR preceded the SSPA, this letter addresses only some of the SSPA changes. It should be noted, however, that the Committee has not yet reviewed the SSPA report, although we do currently have access to it.

In conducting its vertical slice review of the TSPA-SR, the Committee adopted an approach to: (1) determine the principal drivers of the assessed repository performance (including the supporting evidence) working from the final results, and (2) examine the extent to which the assessment achieves a risk-informed result.

### **Review Findings**

In developing the TSPA-SR, DOE performed an extensive amount of modeling, and the results and supporting technical bases are reasonably well displayed in the context of the models employed. However, based on the Committee's vertical slice review, the principal findings are that the TSPA-SR does not lead to a realistic risk-informed result, and it does not inspire confidence in the TSPA-SR process. In particular, the TSPA-SR reflects the input and results of models and assumptions that are not founded on a realistic assessment of the evidence. The consequence is that the TSPA-SR does not provide a basis for estimating margins of safety.

### **Discussion**

The Committee's principal concerns with the TSPA-SR are that: (1) modeling is guided by an inconsistent set of assumptions, including a mixture of conservative and nonconservative bounding assumptions, that do not represent realistic conditions; (2) the TSPA-SR relies on many assumption-based computations and analyses that do not support or link the assumptions with the available evidence; and (3) the TSPA-SR does not provide a sequence model of dominant dose contributors, therefore, it is not transparent or well-integrated.

The following paragraphs summarize representative examples of the problems that the Committee's vertical slice review identified in the TSPA-SR, along with the Committee's recommendations.

**The TSPA-SR relies on modeling assumptions that mask a realistic assessment of risk.**

Among such assumptions are those having to do with such phenomena as radionuclide solubilities, in-package chemistry (including the formation of secondary mineral phases), cladding unzipping, decoupling of the drip shield model from the waste package model, and transport of radionuclides through the geosphere. Other assumptions that mask a realistic assessment and reasonableness have to do with mixing conservative and nonconservative bounding analyses and the general treatment of uncertainty. While the TSPA-SR analysts clearly recognize the masking problem and the modeling inconsistencies with respect to realistic assumptions, they fail to convey the expected risk, based on the available evidence.

The Committee believes that the TSPA-SR is driven more by an attempt to demonstrate compliance with the standards than by the need to provide an assessment designed to answer the question: What is the risk? The result is that the assessment does not really risk-inform the safety of the repository even in the spirit of DOE's own words, "... the goal of performance assessment is to provide decisionmakers with a *reasonable* estimate of the *realistic* future performance of the disposal system and a clear display of the extent to which uncertainty in the present understanding of the system affects that estimate." (The italics are added.)

The stated DOE practice is to choose parameter distributions that are "deliberately conservative" where uncertainty distributions "cannot be adequately justified based on available information." To suggest that the distributions are conservative implies some knowledge about the underlying processes, and how the results are affected by parameter values. While this approach may be suitable under some circumstances, when modeling involves linear systems and independent processes, the application of this approach to the high-level waste (HLW) repository at Yucca Mountain may be flawed. This is because the underlying processes in the near field of the repository, for example, are not entirely linear or independent. To the contrary, significant coupling is expected among nonlinear hydrological, chemical, and thermal processes. Determining what is conservative and what is not under these conditions is neither intuitive nor straightforward.

The masking of realism in the TSPA-SR precludes providing a clear basis to estimate the margins of safety, or making an objective regulatory decision that is in the best public interest.

We note that the SSPA report prepared following the TSPA-SR addresses both information and modeling uncertainties, describes how simplified and bounding models in the TSPA-SR, in some cases, were replaced in the SSPA with more detailed and representative models, and compares supplemental model results with those from the TSPA-SR. The Committee has not reviewed the SSPA and cannot comment on the quality of its results at this time. Nonetheless, there are some notable differences between the results of the SSPA and TSPA-SR models. In particular, the calculated doses for late times have significantly decreased in the SSPA models compared to the TSPA-SR models in the nominal case scenario, and increased for the disruptive case scenario. DOE claims that the differences between the supplemental SSPA

model and TSPA-SR have essentially no impact on conclusions that might be drawn with respect to comparisons with the dose standard.

**Computations and analyses are assumption-based, not evidence-supported.** The TSPA-SR seems to rely more on assumption-based computations and analyses than on the available evidence. This has resulted in limitations that concern the Committee, especially as they relate to: (1) coupled processes, (2) waste package failure, and in-package physical and chemical processes leading to mobilization of the waste, (3) uncertainty in amounts and rates of radionuclides released, and (4) uncertainty in the source term for radionuclide transport. A specific example of relying on assumptions without supporting evidence is an attempt in the TSPA-SR to compare “degraded” and “enhanced” scenarios to provide an indication of the impact on results of two different assumption sets. The idea is a good one and greatly facilitates the understanding of the impact of different assumptions. Nonetheless, the analysis lacks the linkage between the assumption sets and the supporting evidence. The real issue is what the evidence supports, not what are the possibilities? Working from 5<sup>th</sup> and 95<sup>th</sup> percentiles of bounding parameter uncertainties in the TSPA-SR does not have much to do with “pessimistic” and “optimistic” results. It would have been much more informative if the TSPA-SR provided sensitivity analyses with respect to parameter values that are probabilistic, but also realistic, reasonable, and supported by evidence. The idea is to move in the direction of “evidence-supported” analyses and away from “assumption-based” analyses.

An alternative approach would be to select several performance scenarios for each of the nominal and disruptive cases, and emphasize the evidence supporting each individual scenario. The three peak-dose models (scenarios) considered in the TSPA-SR represent the beginning of such an approach, but fail to discriminate among the scenarios in terms of their likelihood and supporting evidence. Clearly defined scenarios can greatly facilitate the general question of what the evidence may or may not support.

**A dominant sequence model has not been developed.** There is a need to abstract a simple model for the dominant dose contributors to the critical group that clearly illustrates how the major modules of the TSPA-SR are integrated and assembled from the detailed models that make up the TSPA-SR. The absence of a simple model for the dominant dose contributors greatly handicaps verification and confidence in the performance assessment results. This is particularly true with regard to evaluating the roles of the different components of the repository system.

In the reactor risk assessment field, the industry has had considerable success in developing simplified risk models based on the dominant contributors to risk (sometimes referred to as a dominant sequence model). These models have contributed to better understanding of the real risk and the contributing factors. They lend themselves to repetitive calculations for checking results. They have also greatly facilitated the review process by allowing simple tradeoffs to be made in assumptions and design conditions while building confidence in the results. There does not appear to be a counterpart to these models in the performance assessment models employed in the TSPA-SR.

The complexity of the TSPA-SR model compromises the ability to comprehend and develop confidence in the results. There are few radionuclides (Tc, I, Np, and Pu) that are driving the risk, suggesting a great opportunity to abstract a simple model. One interpretation of a simple

model would be to simply trace the radionuclide Tc for early dose results (say up to 40,000 years) and Np dose calculations for late and peak doses ( $10^5$  to  $10^6$  years). The adoption of “pinch points” by the DOE investigators is a move in the right direction to show continuity in the analysis and to modularize the models for greater transparency. The problem for the TSPA-SR is that the idea was implemented too selectively to facilitate putting all the pieces of the model together.

## **Recommendations**

On the basis of its vertical-slice review of the TSPA-SR, the Committee recommends that the NRC staff take the necessary action to be assured that:

- The performance assessment of the proposed Yucca Mountain repository is, in fact, risk-informed.
- DOE has adopted an evidence-supported approach and realistic modeling assumptions for use in the TSPA-SR while reducing the dependence on parameter bounding and conservatism to overcome uncertainty and increase the reliance on such available evidence as site-specific field and laboratory data, natural analogs, and expert knowledge.
- The NRC staff’s review of the TSPA-SR adequately emphasized waste package failure and in-package processes to assure the staff that the waste package can perform as DOE claims and to inspire confidence in the characteristics of the source term for radionuclide transport.

The Advisory Committee on Nuclear Waste is prepared to discuss these issues with the NRC staff.

Sincerely,

**/RA/**

George M. Hornberger  
Chairman