UNITED STATES
NUCLEAR REGULATORY COMMISSION
ADVISORY COMMITTEE ON NUCLEAR WASTE AND MATERIALS
WASHINGTON, D.C. 20555-0001

ACNWMR-0276

November 30, 2007

The Honorable Dale E. Klein
Chairman
U.S. Nuclear Regulatory Commission
Washington, DC 20555-0001

SUBJECT: TOTAL SYSTEM PERFORMANCE ASSESSMENT CODE VERSION 5.1

Dear Chairman Klein:

NRC staff from the Division of High-Level Waste Repository Safety and the Center for Nuclear Waste Regulatory Analyses (CNWRA) briefed the Advisory Committee on Nuclear Waste and Materials (the Committee) on version 5.1 of the NRC Total-System Performance Assessment (TPA) computer code. TPA 5.1 has been developed to increase staff readiness and capability to review a potential license application from the U.S. Department of Energy (DOE) for a high-level waste repository at Yucca Mountain. Compared to previous versions, TPA 5.1 is designed to provide greater flexibility in assessing alternative features, events, and processes as well as improved integration of components. The staff will use TPA 5.1 as one of its tools to assist in the review of the license application.

According to the staff, the primary considerations in developing the revised code were (1) the integration of process abstractions for the drift degradation scenario, (2) the methodology for low-probability seismic event sampling, (3) long-term climate and net infiltration, (4) an improved basis for parameter values, and (5) input and output transparency and traceability.

The NRC staff reported that TPA 5.1 includes updates made through January 2007. Staff presentations provided an overview of the code revisions but gave no results from simulated performance of the proposed Yucca Mountain repository.

The staff also reported that TPA 5.1 includes revisions for eight major topics. Four topics that were not discussed in detail at the meeting are updated dosimetry (International Commission on Radiological Protection, 1996), incorporation of glass waste form dissolution, repository layout, and the addition of a 1-million-year simulation period. The Committee does not anticipate a briefing on these topics. The staff did provide a briefing to the Committee on four other topics, summarized below.

Drift Degradation and Seismicity

Engineered barrier system models have been updated to include consideration of drift degradation processes. For example, the thermal model to analyze waste package, drip shield, and drift wall temperatures has been revised to consider the potential accumulation of rubble on drip shields over time. A model also has been added to evaluate the potential consequences of drip shield collapse and damage to waste packages. The new models consider the effects of rockfall, rubble consolidation, and the damage to engineered barriers by seismic events.

Near-Field Environment and Corrosion Processes

The staff has implemented an updated computational approach to determine the number of failed waste packages having the potential to contribute to radionuclide release under nominal conditions. This approach considers the likelihood of water contacting waste forms beneath damaged drip shields and waste packages, and the initiation of localized corrosion on the waste packages. It is anticipated that a future briefing to the Committee will address corrosion.

Colloidal Releases

A new colloidal source and transport model has been developed. Radionuclides both reversibly and irreversibly sorbed to colloidal surfaces are now tracked as unique species. The geosphere radionuclide transport model has been adjusted to simulate the transport of colloids, so that the performance assessment calculations include the colloidal radionuclides.

Volcanic Ash Dispersion and Redistribution Processes

In contrast to previous codes, TPA 5.1 uses a wind rose, incorporating variations in the direction and speed of winds, which more realistically accounts for airborne transport and remobilization of volcanic ash by wind-driven forces. Ongoing CNWRA experimental studies of remobilization and entrainment of volcanic ash at a recent volcano in Arizona (the Sunset Crater) are providing important information on the resuspension of ash that is being considered for incorporation into the revised code. Resuspension makes the ash available for inhalation. Previous studies on resuspension by Anspaugh, et al. (2002), find that there is a very rapid decline in resuspension with time.

The staff reported that it is planning updates to the TPA code in the near future. These updates will include code maintenance, changes in parameter values, and the ability to perform postprocessing calculations regarding seismic analysis. The staff does not plan to modify the TPA 5.1 code after DOE submits a potential license application.

OBSERVATIONS

The Committee makes the following observations:

- The Committee believes that the staff has made significant progress in improving its performance assessment capability with TPA 5.1. This is a key step to enhancing the NRC's capabilities to conduct a risk-informed, performance-based review of a DOE license application for Yucca Mountain.

- An important goal in preparing TPA 5.1 was to increase the flexibility of the code so that alternative views, processes, and parameters could be incorporated into the assessments. The Committee believes that the staff has met this goal and commends the staff for providing for this flexibility in the performance assessment.

- The staff reported that eight topics received special attention in the revision of the TPA code. It is timely and appropriate to have revised these topics to better address the current scientific and technical understanding and proposed changes in the U.S. Environmental Protection Agency (EPA) standard for Yucca Mountain (e.g., extension of the compliance period to 1 million years).

- The staff reports that TPA 5.1 could be used to update portions of the Risk Insights Baseline Report published in 2004. This is an important role for the TPA because the updated risk insights will assist in focusing the staff's review of the pending license application. For example, as explained by the staff, the risk update can be used to focus NRC review of the multiple barrier capabilities as determined by the DOE performance assessment and to determine the technical basis for the DOE description of barrier capability. The Committee believes that a reevaluation of the risk insights is important to the review of the license application in view of the progress in understanding the technical basis for many of the topics important to safety at the proposed repository and the proposed modifications to the EPA standard.

- The integration of processes and parameters was a goal of the revision of the code, and the staff reported making significant improvements to achieve this goal. However, it appears that coupling some of the processes and parameters between scenarios requires manual data entry. The Committee believes that the need for manual data entry requires precautionary statements in the user's guide and preferably in the code itself where the code does not automatically couple processes and parameters.

- The staff reported that it will not revise the code, which was "locked" in January 2007 as TPA 5.1, after the Yucca Mountain license application is docketed. "Locking" the code after docketing of the license application may not provide adequate flexibility for addressing new information. In view of ongoing studies on such topics as drift degradation, igneous activity, and seismic hazards, providing for the ability to update the TPA should make it more useful in reviewing the license application.

- The staff reported that it would not perform direct comparisons of outputs from the DOE and NRC performance assessment codes. The TPA results are not intended to make direct comparisons but rather to develop risk insights information to aid the staff's evaluation of the applicant's performance assessment calculations.

- The user's guide for TPA 5.1 (NRC, 2007) shows that the base-case data set uses the same size distribution for volcanically ejected spent fuel that was used in TPA 4.1j (i.e., a log-triangular distribution of particle sizes ranging from 1 to 100 microns and a mean of 10 microns). The Committee disagrees with the use of this particle size distribution (ACNW&M, 2007; Executive Summary and Section 6.3.3).

RECOMMENDATIONS

The Committee believes that TPA 5.1 is an improvement over previous versions of the code and will enhance the NRC's ability to review the pending license application and evaluate the technical basis for the components of the DOE performance assessment, as consistent with the Yucca Mountain Review Plan. The Committee has the following recommendations to improve TPA 5.1 and its use in an independent review of the license application:

- The Committee recommends that the updates to TPA 5.1 be documented and integrated with the Risk Insights Baseline Report. This update could take the form of a separate document, interim staff guidance, or an update to the Risk Insights Baseline Report.

- The Committee believes that the user's guide for the code should incorporate cautionary statements regarding the fact that the code does not automatically couple processes

between scenarios and that coupling must be implemented by manual data entry. Consideration should be given to displaying these cautionary statements to the user to avoid misunderstandings in the use of the code.

- In view of the continuing improvement in the understanding of the processes and parameters in, for example, drift degradation, igneous activity, and seismic hazards, provision should be made to permit minor modifications to the code and the staff's recommended input parameters listed in the code. This would provide the opportunity to incorporate important developments in potentially high-risk topics even after the pending Yucca Mountain license application is docketed.

- The Committee recommends that the staff reexamine the realism of the assumed range of spent fuel particle sizes that is used in the volcanism extrusion scenario within TPA 5.1.

The Committee commends the staff on the preparation of the revised TPA code. It should increase the staff's readiness and capability to review a potential license application for a high-level waste repository at Yucca Mountain.

Sincerely,

/RA/

Michael T. Ryan
Chairman

References:

1. ACNW&M (2007). "Igneous Activity at Yucca Mountain: Technical Basis for Decisionmaking." White paper available online at: http://www.nrc.gov/reading-rm/doc-collections/acnw/letters/2007/.

2. Anspaugh, L.R., Simon, S.L., Gordeev, K.I., Likhtarev, I.A., Maxwell, R.M., and Shinkarev, S.M. (2002). "Movement of Radionuclides in Terrestrial Ecosystems by Physical Processes," *Health Physics*, 82(5): 669–670.

3. International Commission on Radiological Protection (1996). "Age-Dependent Doses to the Members of the Public from Intake of Radionuclides: Part 5, Compilation of Ingestion and Inhalation Coefficients," ICRP Publication 72, Elsevier.

4. NRC (2007). "Total-System Performance Assessment (TPA) Version 5.1 Module Descriptions and User Guide," ADAMS Accession No. ML0727100600.

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4. NRC (2007). "Total-System Performance Assessment (TPA) Version 5.1 Module Descriptions and User Guide," ADAMS Accession No. ML0727100600.

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LETTER TO: The Honorable Dale E. Klein, NRC Chairman

FROM: Michael T. Ryan, ACNW&M Chairman

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Date: November 30, 2007

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