UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D.C. 20555-0001

October 30, 1998

Dr. B. John Garrick, Chairman
Advisory Committee on Nuclear Waste
U.S. Nuclear Regulatory Commission
Washington, DC 20555

SUBJECT: ISSUES AND RECOMMENDATIONS CONCERNING THE NEAR-FIELD ENVIRONMENT AND THE PERFORMANCE OF ENGINEERED BARRIERS AT YUCCA MOUNTAIN

Dear Dr. Garrick:

We are responding to your letter of September 9, 1998, to Chairman Jackson, providing the Advisory Committee on Nuclear Waste's (hereafter the Committee's) observations and recommendations on issues related to the performance of the engineered barrier system (EBS) for the proposed Yucca Mountain High-Level Radioactive Waste (HLW) repository. The Committee's letter, in part, expands on recommendations made in a prior letter to the Chairman (dated October 8, 1997) reporting on the evaluation of the U.S. Nuclear Regulatory Commission's (NRC's) performance assessment (PA) capability in the HLW program area.

The staff shares the Committee's view that EBS is a key element of a multiple-barriers approach for licensing a geological HLW repository. Further, we agree that NRC's review of the license application (LA) will need to address the adequacy of the U.S. Department of Energy's (DOE's) concepts, data, and models used to support calculations of the EBS' performance. The staff is, in fact, evaluating DOE's approach to support the EBS performance estimates in its day-to-day activities related to identifying and resolving key technical issues (KTIs) and in its review of the DOE Total System Performance Assessment-Viability Assessment (TSPA-VA).

Beyond the Committee's four fundamental recommendations (addressed in the first four numbered sections, following), your letter identified more than 20 specific technical issues in water flow and chemistry, corrosion, and radionuclide release and transport, that need further consideration. The majority of the Committee's concerns with specific technical issues are addressed in our responses to the Committee's four fundamental recommendations. The Committee's remaining specific technical issues are addressed in the fifth section, below.

RECOMMENDATION 1. The Committee recommends that the Office of Nuclear Material Safety and Safeguards (NMSS) evaluate its expertise in areas critical to the performance of the EBS and quality assurance/quality control (QA/QC) and augment the currently available expertise, where needed, by reinforcing NMSS with staff from other NRC offices, by hiring from the outside, or by engaging expert consultants. Total systems engineering (refer also to recommendation 3, below) and chemical processes in the drift, including colloid chemistry, are two areas suggested by the Committee where the staff may need additional expertise.

RESPONSE 1. As indicated in your letter, the Committee understands that NMSS is taking action to enhance its QA/QC capability. In addition, the Committee recognizes NRC's and the Center for Nuclear Waste Analyses' (CNWRA's) existing capabilities in water flow and chemistry, corrosion, and radionuclide release and transport. As the Committee is aware, the

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staff responded decisively to the Committee concerns raised in its October 8, 1997, letter to the Chairman, regarding support to EBS-related KTIs whose funding had previously been cut. It is noteworthy that both the NRC and CNWRA staffs have been augmented in the pertinent areas identified by the Committee. Our staff additions, through internal transfers and new hires, include personnel with expertise in nuclear, chemical, environmental, and materials engineering. In addition, CNWRA has augmented its staff with a materials scientist with corrosion expertise and two chemical engineers with expertise in formulation and behavior of vitrified waste forms. Aggressive recruitment is ongoing for an experimentalist and a numerical modeler in the area of container life and source term (CLST), a mechanical engineer who will enhance capabilities to address both preclosure design and rock/waste-package interactions, and a geochemist with expertise in colloids.

RECOMMENDATION 2. The Committee recommends that the KTI and subissue activities related to the EBS components and functions be reexamined, using risk insights gained from PA and other risk analysis techniques. Staff efforts to identify and bound near-field environment processes, and to address fabrication and welding issues, as well as the overall breadth and flexibility of the KTI program, are the technical areas of concern to the Committee.

RESPONSE 2. The staff believes it is carrying out this recommendation and is addressing the technical concerns in its ongoing PA (refer also to the response to recommendation 4 below) and KTI activities. The staff agrees on the importance of identifying and bounding near-field environment processes, especially those critical to waste package (WP) and source term performance. Near-field processes that are important to performance are vitally dependent on repository design, including WP materials and their fabrication, and repository operations (length of preclosure period and ventilation), both of which have continued to be constantly changing variables within the DOE program. EBS-related KTI teams have adopted a flexible approach to address the processes in PA, in experimental and modeling studies, and in defining both the subissues and the acceptance criteria contained in the Issue Resolution Status Reports (IRSRs). Both the design option and its details are likely to change before DOE submits its LA and, potentially, during the operations of the repository. Thus, at this time, the flexible iterative PA approach is more robust than one that extensively focuses on the details of a particular design option. History supports the appropriateness of this strategy, and insights in DOE plans suggest a continuing need for such flexibility in the future.

The Committee provided technical issues of concern on bounding the environment for the corrosion-resistant material (CRM), assessing the potential for crevice corrosion of the CRM, and determining the range of effects of coupled processes on the WP. We are addressing these issues within the CLST and "Evolution of the Near-Field Environment" KTIs, using risk insights gained from PA. Acceptance criteria covering these concerns are contained in the respective IRSRs. Likewise, the Committee's technical concerns with the long-term performance of cladding and appropriate mobilization rates for the repository source term (refer also to the response to recommendation 5, below) are being addressed in both the PA and KTI activities of the EBS-related KTIs. In addition, CNWRA and NRC staffs are evaluating the validity of the critical-temperature approach for assessing the performance of the recently proposed CRM of the WP.

Fabrication of WPs and the potential importance of welding issues to repository performance are specific EBS technical issues that the Committee listed as needing to be reexamined by staff. We are continuing to examine this issue, and the results of our PA show the potential

importance of juvenile failures. The Committee suggested that DOE should provide weld reliability data, and the NRC staff should be prepared to address issues associated with fabrication QA and the eventual need for technical specifications and QA for WP welds. Fabrication and weld concerns are already included in acceptance criteria within the CLST IRSR, and additional focused work on the weld issue will be conducted during fiscal year (FY) 1999. As the WP design becomes finalized for the DOE LA, and based on risk insights gained from PAs, the level of QA required and the extent of WP technical specifications will be determined. Finally, the Committee stated that evaluating the bases for DOE's model abstraction and review of DOE's model verification process are important aspects of regulatory review. We agree, and as the Committee is aware, these activities are within the breadth of current KTI activities and are addressed in all the IRSRs, not just those related to EBS.

RECOMMENDATION 3. The Committee recommends that NRC staff should develop a systems engineering capability to allow it to use a total systems engineering approach in its evaluation of DOE's TSPA-VA, and, in particular, DOE's LA. The Committee also comments that it sees a need for additional expertise in "application of total systems engineering principles" and "engineering modeling."

RESPONSE 3. Systems engineering principles are deeply ingrained in both the regulatory and technical aspects of the NRC HLW program. Although many staff members have formal training and several have degrees in systems engineering, the principles have been applied across the staff, in combination with their scientific and engineering expertise. Furthermore, a significant effort was expended in the late 1980s to ensure that the NRC and CNWRA staffing, organization, and technical approach to executing the HLW program were firmly based on sound systems engineering principles. The approach the staff has adopted is preferred to that where a separate group of systems experts develops procedures, protocols, and models that are often not embraced nor used by the staff that are on the front line of project execution. An NRC-CNWRA team comprising a wide range of technical disciplines, which provides both systems and process knowledge and in-depth technical expertise, develops total-system models. Given the systems-based foundation of the NRC HLW program, I see no apparent regulatory or technical need for additional focused expertise in systems engineering.

In addition to the preceding comments, we firmly believe that the staff's capabilities in "engineering modeling" and "engineering science" are comparable to those in the earth sciences. Although the availability of staff to work on engineering aspects of the HLW program was sharply curtailed in FY 1996-1997, because of a 50 percent cut in the NRC HLW budget, staff was largely retained by diverting them to other projects, and is now returning to the repository program and is being augmented, as previously noted. Despite these negative impacts on staffing, we have provided timely commentary to DOE on the most critical topics and have, within the past year, become fully engaged in developing the conceptual and mathematical models necessary to evaluate the performance of the engineered components of the repository.

The staff concurs in the three topical areas (WP environment scenarios, corrosion models, and alternative designs) that the Committee suggests be considered. Under the current operating plans for the NMSS HLW program, we will address each of these topics during FY 1999-2000. Regarding the suggestion that "... quantitative modeling of canister corrosion will require close attention to the engineering details," we generally agree. Many aspects of WP life prediction will require close attention to engineering details; however, the DOE engineering design

continues to evolve with time, so focus on specific details is difficult. In fact, Volume 4 of the VA (the License Application Plan) is projected to contain at least 12 different design options, the most preferred of which will not be the base case design evaluated in the TSPA-VA. Because of the uncertainties in detailed engineering design, NRC and CNWRA have developed robust corrosion models that we can apply to a variety of materials, by only changing the input parameters. For example, repassivation and corrosion potentials determine the initiation of localized corrosion, and a galvanic efficiency parameter determines the galvanic interactions. These parameters, which may be classified as engineering models, are then supported by more fundamental investigations of processes affecting localized corrosion. In addition, long-term corrosion tests are conducted under well-defined conditions so that confidence in the engineering parameter is increased. In FY1999, the approach will be extended more fully to alloy C-22 and to new materials DOE is considering for the LA design.

RECOMMENDATION 4. The Committee recommends that NRC staff should position itself, through importance analysis or other risk-based techniques, to evaluate the contribution of individual barriers to the overall system performance.

RESPONSE 4. The staff agrees and will continue its ongoing efforts in this area. The PA and EBS-related KTIs currently use both intermediate outputs from the Total System Performance Assessment (TPA) code, and sensitivity studies using the TPA code, to evaluate the contribution of individual barriers to the overall system performance. In addition, we have previously provided the Committee with details of PA efforts to evaluate various methodologies that will permit the systematic evaluation of results and the identification of specific contributors to performance.

RECOMMENDATION 5. The Committee, in its discussion of radionuclide release, states that continuing work on secondary phases and colloids, including what it refers to as "confirmatory research," at the CNWRA, is needed. Additional work areas the Committee suggests include enhancing the thermodynamic database for secondary uranium phases, and studies of other potential solid phases with key radionuclides [especially neptunium (Np)].

RESPONSE 5. We appreciate the Committee's recognition of NRC's past work on secondary uranium phases associated with the Peña Blanca natural analog site and the incorporation of that information into PA. In addition, we agree with the potential importance of mobilization rates and the role of secondary uranium minerals on repository performance. We have already specifically planned to study secondary uranium phases and co-precipitation of Np into these phases, at the CNWRA during FY 1999, although in a limited manner. Evaluation of the potential importance to performance resulting from uncertainty in the existing thermodynamic database for secondary uranium phases is ongoing. No experimental work on colloids is planned, but some effort will be made to better incorporate the potential importance of colloids in PAs of the repository. We recognize that our current experimental effort on source term issues is limited, but it is commensurate with our current budget, the role of DOE as license applicant, and NRC's regulatory responsibilities. In this time of limited budgets, expansion of the scope of work in this particular area would require reduction of the scope in other areas. We believe that our current program achieves a well-balanced approach. If the Committee recommends expansion of the scope of work in one program area, it would be helpful if it also provided information on other areas of the HLW program that could be reduced consistent with the Nuclear Waste Fund budget. We would welcome further discussion on this issue, and we will be briefing you on our priorities at your December meeting.

The staff appreciates the Committee's observations and recommendations on issues related to the performance of the EBS for the proposed Yucca Mountain HLW repository. As detailed herein, the staff is actively engaged in carrying out the recommendations in its day-to-day KTI and PA activities and believes that its activities address evaluation of the adequacy of DOE's concepts, data, and models used to support the EBS performance.

Sincerely,

Original Signed by
William D. Travers

William D. Travers
Executive Director
for Operations

cc: Chairman Jackson
Commissioner Diaz
Commissioner McGaffigan
Commissioner Merrifield
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