UNITED STATES
NUCLEAR WASTE TECHNICAL REVIEW BOARD
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August 31,2000

Honorable Joe Barton
Chairman
Subcommittee on Energy and Power
Committee on Commerce
U.S. House of Representatives
Room 2125, Raybum House Office Building
Washington, DC 20515-6115

Dear Mr. Barton:

Enclosed are responses to the questions posed in your letter of July 20,2000, to Dr. Debra Knopman following her appearance before the Subcommittee on Energy and Power on June 23,2000. The Board provides independent advice on the technical issues associated with the management of the country's commercial spent nuclear fuel and defense high-level radioactive waste. The Board offers its technical views to help inform the larger consideration of issues that faces the Department of Energy and the Congress in their evaluation of the suitability of the Yucca Mountain candidate repository site.

The Board is keenly aware that many of the issues that must be considered in making decisions in this policy area are technical ones, but others are not. Regarding site suitability, we believe that Congress and the Secretary will find it useful to have our views on the adequacy of current information to technically support a possible site recommendation. As noted in our responses, a site recommendation can be made at any time, depending in part on how much uncertainty policy-makers are prepared to accept.

Please let me or the Board's staff know if we can provide you or your staff with any additional information on the enclosed responses.

Sincerely,

Jared L. Cohon
Chairman

Enclosure

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NUCLEAR WASTE TECHNICAL REVIEW BOARD RESPONSES TO QUESTIONS FOR THE RECORD FROM MR. BARTON AUGUST 31,2000

1. Is the Technical Review Board concerned that funding constraints are causing DOE to postpone or skip critical technical analyses necessary to support the site recommendation and licensing decisions? If so, please identify the specific areas that are not being addressed adequately by DOE.

The Board's congressional mandate is statutorily limited to reviewing the technical and scientific validity of Department of Energy (DOE) activities. Therefore, the Board has not examined the details of DOE's budget for Yucca Mountain research or its funding allocations for program operation, management, procurement, and contracting. Consequently, the Board cannot judge the extent to which the Yucca Mountain site characterization and repository design activities have been or will be constrained by budget limitations. What is clear, however, is that the Board's present understanding of a potential repository located at Yucca Mountain is affected by many policy-related factors, including congressional appropriations, DOE's research and program priorities, and statutory and administrative deadlines, as well as the significant challenge of undertaking a first-of-a-kind activity.

Because less than a year remains before the scheduled site-recommendation decision in July 2001, the amount of additional scientific and technical work that can be completed by that date is very limited. Thus, the information available in July 2001 for a site recommendation will in all likelihood not be appreciably affected by whatever budget Congress passes for FY 2001. However, funding constraints in DOE's budget for FY 2001 and beyond could limit ongoing and new work that might support a DOE license application for repository construction.

The Board reviews the scientific and technical program as it is and makes its technical judgments accordingly. On the basis of information it has reviewed to date, the Board believes that the technical basis for DOE's current long-term projections of repository performance has critical weaknesses. These projections and their associated weaknesses reflect in part the DOE's "base-case" (above-boiling) repository design. Although the site may, in fact, merit a positive site recommendation, DOE has not yet demonstrated—for the base-case design—a firm technical basis for that conclusion.

Some of the current large uncertainties about waste package and repository performance are directly or indirectly related to the high (i.e., above-boiling) repository temperatures associated with DOE's current base-case design. High temperatures increase the level, extent, and significance of the combined, or "coupled," effects of thermal, hydrologic, mechanical, and chemical processes. Furthermore, the waste packages may be more vulnerable to corrosion at higher temperatures if water is present. The Board believes that it will be very difficult for the DOE to improve substantially its current Understanding of these high-temperature effects during the next year or two. However, it may be possible over the next several months to reduce some uncertainties, for example, by developing a defensible technical basis for a lower-temperature repository design.

In addition to the effects of high temperatures, some uncertainties are related to a lack of fundamental understanding about physical processes that will extend over thousands of years; realistic predictions are therefore very difficult to make. For example, the performance of the waste packages over thousands of years has been extrapolated from a few years of corrosion data and too limited an understanding of fundamental corrosion processes. Finally, the characterization of the hydrogeology below the repository horizon, although supported by some data, continues to rest largely on inadequately supported hypotheses. As a result, for example, the flow and transport of radionuclides in the unsaturated and saturated zones from the repository to the accessible environment are poorly understood.

The Board believes that significantly improving the fundamental understanding of these natural features and engineered barriers during the next year or two will be very difficult However, the Board believes that work in these areas is important and should continue. Because of the complexity of the Yucca Mountain site and the challenges involved in extrapolating data over long time periods, gaining such an understanding of these basic processes will take time. Continued adequate funding of these long-term studies will be important.

2. Is it correct that the Technical Review Board is concerned that DOE is not paying enough attention to the uncertainties inherent in the repository's long-term performance, especially with respect to the "hot" repository design?

The persistence of substantial uncertainties has led the Board over the last few years to recommend strongly that DOE develop a more technically defensible basis for making design, site-recommendation, and licensing decisions. In particular, the Board has recommended initiation of fundamental studies on long-term corrosion, evaluation of alternative repository designs, improved characterization of rock formations in the vicinity of Yucca Mountain, examination of radionuclide retardation in the unsaturated and saturated zones below the repository horizon, evaluation of colloidal transport, and investigation of the effect of structures and heterogeneities on water movement above and below the water table. DOE has responded to many of the Board's suggestions, but it has not yet completed all of those studies. Although the Board is encouraged by the level of attention DOE is now giving to the quantification and characterization of uncertainty in estimating repository system performance, the Board also continues to have concerns in this area.

The Board realizes that projecting long-term performance of a potential repository at Yucca Mountain, or anywhere else for that matter, is inherently associated with uncertainty. Eliminating all the uncertainties will never be possible (although they can be reduced). In fact, the Board has noted that a site recommendation can be made at any time, depending in part on how much uncertainty policy-makers are prepared to accept. The timing of the site recommendation, of course, is clearly beyond the Board's charge.

As noted in the answer to question #1, on the basis of information reviewed to date, the Board believes that the technical basis for DOE's current long-term projections of repository performance has critical weaknesses. These projections and their associated weaknesses reflect in part the DOE's base-case (above-boiling) repository design. The Board explicitly raised this concern about above-boiling repository designs in a July 9,1999, letter to DOE's Office of Civilian Radioactive Waste Management. Although the site may, in fact, merit a positive site recommendation, DOE has not yet demonstrated—for the base-case design—a firm technical basis for that conclusion.

Adopting a lower-temperature repository design for commercial spent fuel might mitigate some of the weaknesses associated with projections of long-term repository performance, such as problems associated with coupled processes. A lower-temperature repository design could make projections of performance less dependent on areas where scientific understanding is incomplete. Therefore, DOE should augment its current design evaluations with a rigorous and persuasive evaluation of the performance of, and trade-offs associated with, alternative repository designs, including assessing the effects of the following factors on performance and uncertainty: age of waste at emplacement, spacing between waste packages, ventilation rates and efficiencies, and time before repository closure. It is possible, but not certain, that a cooler, drier, and simpler design than the current base-case design would lower the technical hurdles that DOE now faces in projecting long-term waste package and repository performance.

DOE, however, has not yet carried out a sufficiently thorough evaluation of low-temperature repository designs. By carrying out such an evaluation, DOE would develop a much better understanding of how the thermal characteristics of different designs may affect critical uncertainties (e.g., those associated with coupled processes, the stability of the passive layer of Alloy 22, and the waste package environment). But the magnitude of other uncertainties, such as those associated with the saturated zone under the repository, are very likely to be independent of the facility's design.

3. How would the Board suggest that DOE should take these uncertainties into account—is this a matter of DOE actually changing its repository design, or merely a matter of presenting this uncertainty information to the decision-makers?

DOE intends to base its site-recommendation decision primarily on the results of a total system performance assessment (TSPA), a complex computer model that estimates repository performance many thousands of years into the future. The technical soundness of DOE's site-recommendation decision will therefore depend to a large extent on the technical validity of its TSPA. Put another way, policy-makers* confidence in performance assessment reflects in many ways the level of uncertainty associated with estimates of performance: the greater the uncertainty, the lower the confidence in repository performance may be.

There are several internationally recognized strategies for managing or reducing uncertainties. One strategy involves using "conservative" assumptions and parameters throughout the performance assessment. Thus, if the assessment is in error, the long-term performance of the repository is underestimated, not overestimated. A second strategy involves using multiple lines of evidence independent of performance assessment in developing a "repository safety case." A third strategy involves making repository design choices that minimize uncertainties.

DOE has made progress in implementing each of these three strategies, but it can—and should—do more. For example, it is difficult to know whether the assumptions and parameters used in DOE's performance assessments are truly conservative or how the combination of conservative, optimistic, and realistic estimates affects overall dose calculations and the uncertainties associated with those calculations. As noted in the response to question #6, DOE has not yet completed the evaluation of independent lines of evidence—an evaluation that is needed to increase confidence in the conclusions of its safety case derived from performance assessment. Finally, as noted in the answer to question #2, DOE has not yet performed a rigorous and persuasive analysis of how uncertainty in repository performance varies with repository design.

Regardless of what strategies are used to manage or reduce uncertainty, the Board believes that DOE's projections of repository performance will be incomplete unless DOE also provides a description and a meaningful quantification of the level of uncertainty associated with its predictions. DOE then will be in a better position to make important decisions, including choosing waste package and repository designs having acceptable predictions of performance, and decision-makers will be able to make technically informed choices related to the DOE's work at Yucca Mountain.

4. When does the decision on hot versus cool repository design have to be made? Can DOE leave this decision open into the licensing phase?

For DOE to make a positive site recommendation, the Board believes that DOE would need to make a technically defensible argument that at least one repository design concept, including firm operational assumptions, will perform satisfactorily for thousands of years. Such an argument would presumably consider the associated levels of uncertainty in repository performance. Therefore, the Board assumes that DOE would describe for the site recommendation at least one design concept and a set of operational assumptions with sufficient specificity so that sound and complete assessments of performance can be developed.

The Nuclear Regulatory Commission, of course, will determine whether the particular detailed design or designs used in DOE's license application will, in fact, provide reasonable assurance of satisfactory performance to warrant constructing a facility.

5. A recent GAO report on radiation standards suggested that the cooler repository design favored by the Board could add $2 billion to the cost of the repository. What is the basis for that statement by GAO, and is that estimate correct?

The statements in the GAO report are misleading in two respects. First, although the Board noted in July 1999 that the technical basis supporting any above-boiling repository design was, in its opinion, not strong enough, the Board is not in a position to *recommend* a specific design alternative. In fact, in its June 23, 2000, testimony before the Subcommittee, the Board, explicitly stated,"... more thorough analysis is needed before any judgment is made about the optimal thermal conditions for repository operation."

Second, at the Board's meeting in May 2000, DOE presented some preliminary results and cost estimates related to alternative thermal designs. That analysis suggested that the incremental discounted cost of implementing a below-boiling (as opposed to an above-boiling) design may be as low as $600 million. If, for example, different assumptions were adopted about the distance between repository tunnels, the incremental cost might be reduced even more. This type of result, stimulated by a Board recommendation, is likely to help DOE understand better the technical and economic trade-offs associated with alternative repository designs. Such an understanding is essential for making a sound decision, regardless of what regulatory standard is ultimately established.

6. Please identify any other outstanding technical issues with the repository design that, in the Board's view, are not being addressed adequately by DOE. Explain these concerns fully, and make recommendations on actions that DOE and the Congress should take to resolve these issues.

Unfortunately, DOE's models are not well enough developed or supported by sufficient data to differentiate between the performance of below-boiling and above-boiling repository designs over the next several thousand years. To develop the tools necessary for evaluating these differences, DOE would have to increase substantially its understanding of the coupled thermal, hydrologic, mechanical, and geochemical processes taking place within the repository; the mechanisms and paths by which radionuclides could be transported from the repository tunnels into the unsaturated and saturated zones below; and the data and fundamental knowledge used to project the long-term corrosion susceptibility of waste packages.

Although the Board has endorsed the use of TSPA, in an April 1999 report the Board noted the limits of TSPA calculations and expressed doubt that relying "solely on [performance assessment] to demonstrate repository safety" will ever be possible. Therefore, the Board recommended in this report that DOE develop multiple lines of evidence that can supplement performance assessment.

DOE is working on a repository safety case that is designed to increase confidence that a repository at Yucca Mountain is likely to perform as predicted. The strategy currently rests on six "pillars": performance-assessment calculations, safety margins, analysis of disruptive events, defense-in-depth, natural analogs, and performance confirmation during and after waste emplacement. On the surface, these pillars may appear to satisfy the Board's recommendation that DOE develop multiple lines of evidence that can supplement performance assessment. A closer look suggests otherwise.

To begin with, four of the pillars—performance-assessment calculations, safety margins, defense-in-depth, and analysis of disruptive events—as currently presented are not independent of each other. They are all dependent on performance assessment. Thus, if one lacks confidence in DOE's performance assessment, one is not likely to have much confidence in any of the four pillars. The last two pillars of the repository safety case—natural analogs and performance confirmation—*are* independent of performance-assessment calculations. However, DOE's evaluation of natural analogs so far has been minimal, and performance confirmation is simply a plan of activities that will be subject to future budget and time constraints.