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U.S. NUCLEAR WASTE TECHNICAL  
REVIEW BOARD

Report to  
The U.S. Congress  
And  
The Secretary of Energy



January to December 2000

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UNITED STATES  
NUCLEAR WASTE TECHNICAL REVIEW BOARD  
2300 Clarendon Boulevard, Suite 1300  
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April 2001

The Honorable J. Dennis Hastert  
Speaker of the House  
United States House of Representatives  
Washington, D.C. 20515

The Honorable J. Strom Thurmond  
President Pro Tempore  
United States Senate  
Washington, D.C. 20510

The Honorable E. Spencer Abraham  
Secretary  
U.S. Department of Energy  
Washington, D.C. 20585

Dear Speaker Hastert, Senator Thurmond, and Secretary Abraham:

The Nuclear Waste Technical Review Board submits this *Report to The U.S. Congress and The Secretary of Energy* in accordance with provisions of the Nuclear Waste Policy Amendments Act of 1987, Public Law 100-203, which requires the Board to report its findings and recommendations to Congress and the Secretary of Energy at least two times each year.

Congress created the Board to evaluate the technical and scientific validity of activities undertaken by the Secretary of Energy in characterizing a site at Yucca Mountain, Nevada, for its suitability as the location of a permanent repository for disposing of spent nuclear fuel and high-level radioactive waste. The Board also reviews the Department of Energy's (DOE) work that is related to the design of the repository and to the packaging and transport of spent nuclear fuel and high-level radioactive waste. In this report, the Board summarizes its major activities in calendar year 2000.

During 2000, the Board identified four priority areas for evaluating the potential repository at Yucca Mountain. As summarized by Chairman Jared Cohon at the Board's January 2001 meeting in Amargosa Valley, Nevada, the areas are the following:

- meaningful quantification of conservatisms and uncertainties in the DOE's performance assessments
- progress in understanding the underlying fundamental processes involved in predicting the rate of waste package corrosion

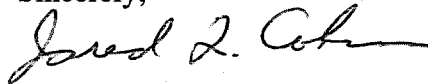
- an evaluation and a comparison of the base-case repository design with a low-temperature design
- development of multiple lines of evidence to support the safety case of the proposed repository, the lines of evidence being derived independently of performance assessment and thus not being subject to the limitations of performance assessment.

This report summarizes the Board's views on each priority area. More-detailed discussions of these areas, as well as of other technical issues, were transmitted to the DOE by letter during the year. The letters are presented in Appendix E of this report.

We believe that the information in this report will be useful to policy-makers as well as to DOE managers and staff when they make important decisions on the status of the Yucca Mountain site and the research priorities of the civilian radioactive waste management program.

We thank you for this opportunity to present the Board's views.

Sincerely,



Jared L. Cohon  
Chairman

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# Board Activities in 2000

During 2000, the U.S. Department of Energy (DOE) continued characterizing Yucca Mountain in Nevada to evaluate the suitability of the site for constructing a mined geologic repository for the permanent disposal of spent nuclear fuel and high-level radioactive waste. The DOE continued preparing designs of the packages for disposing of the waste and a design of the subsurface repository facilities. An updated total system performance assessment was completed, and testing continues inside the tunnels of Yucca Mountain.

The U.S. Nuclear Waste Technical Review Board (Board) is charged under the Nuclear Waste Policy Amendments Act of 1987 (U.S. Congress 1987) with evaluating the technical and scientific validity of the work undertaken by the DOE to develop a system for disposing of spent nuclear fuel and high-level radioactive waste. In this report, the Board summarizes its activities in 2000. During the year, the Board identified four priority areas. As summarized by Chairman Jared Cohon at the Board's January 2001 meeting in Amargosa Valley, Nevada, the areas are the following:

meaningful quantification of conservatisms and uncertainties in the DOE's performance assessments

progress in understanding the underlying fundamental processes involved in predicting the rate of waste package corrosion

an evaluation and a comparison of the base-case repository design with a low-temperature design

development of multiple lines of evidence to support the safety case of the proposed repository, the

lines of evidence being derived independently of performance assessment and thus not being subject to the limitations of performance assessment.

Section I of the report summarizes the Board's views on each priority area. More-detailed discussions of these areas, as well as of other technical issues, were transmitted to the DOE by letter during the year. The letters are presented in Appendix E of this report.

## I. Board Priorities

### A. Meaningful Quantification of Uncertainties

The Board believes that meaningful quantification of the uncertainties associated with estimates of repository performance, presented clearly and understandably, is essential to give policy-makers who are deciding on a site recommendation critical information on trade-offs between projected performance and uncertainty in the projections. The Board made several suggestions in 2000 to assist the DOE in this task. The Board was encouraged by the efforts made by the DOE during the year but cautions that additional efforts are needed before a case can be made that uncertainties have been estimated in a technically credible manner.

A closely related issue requiring further thought is the adoption of a mix of conservative, realistic, and optimistic assumptions in models and parameters. Determining the overall level of conservatism for a mix of conservative, realistic, and optimistic assumptions will be very difficult. If the DOE believes that a performance assessment is conservative, an



effort must be made to provide a defensible estimate of the overall level of conservatism.

The Board realizes that any projection of long-term performance of a potential repository at Yucca Mountain is inherently uncertain; eliminating all the uncertainties will never be possible (although they can be reduced). The Board also realizes that policy-makers can make a decision on whether to recommend the site at any time, depending in part on how much uncertainty they find acceptable. The Board believes, however, that developing methods for quantifying uncertainties in the DOE's performance assessments should be a priority area of work for the Yucca Mountain Project so that policy-makers will have a clearer basis for making their decisions.

### **B. Understanding Fundamental Corrosion Processes**

Sensitivity and neutralization studies indicate that the waste package may be the most important barrier for containing and isolating radioactive waste. Therefore, the data, models, and assumptions pertaining to waste package performance deserve special scrutiny.

There have been significant improvements in waste package data and models since the performance assessment for the DOE's 1998 Viability Assessment (DOE 1998). For example, a major advance is the model relating the presence or absence of water on the outer surface of the waste package to relative humidity at temperatures above the boiling point. Similarly, the long-term-corrosion testing facility at Lawrence Livermore National Laboratory has improved the data set from which corrosion rates are estimated. Nevertheless, extrapolation of corrosion rates determined from short-term (a few years) experiments to predict waste package performance over tens of thousand of years is a subject of considerable uncertainty. Long-term extrapolations may be suspect if they are made with little or no understanding of the fundamental mechanisms that either preserve or dissolve the passive layer that is critical to the corrosion resistance of Alloy 22. If possible, such understanding should be accompanied by examples of long-term (in a geological sense) protection by passive layers in aggressive environments.

Processes that could affect the long-term viability of the passive layer include the following:

Passive layer defect accumulation: Will the passive layer encounter microscopic defects as it sweeps into metal?

Passive layer debris accumulation: Will corrosion products have long-term effects on the passive layer?

(Quasi)transpassive dissolution: If the open-circuit potential creeps up over time, will transpassive regimes be approached, promoted by the high molybdenum content of Alloy 22?

Progress in understanding these fundamental processes is needed to support long-term predictions of waste package corrosion.

### **C. Comparison of Base-Case and Lower-Temperature Repository Designs**

Some of the current large uncertainties about waste package and repository performance are directly or indirectly related to the high (above-boiling) repository temperatures associated with the DOE's current base-case repository 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 several months to reduce some uncertainties for example, by developing and evaluating a lower-temperature repository design.

The Board is interested in obtaining an evaluation and a comparison of the base-case, high-temperature repository design with a low-temperature, ventilated design. Evaluating a possible low-temperature, ventilated design could clarify the advantages and disadvantages associated with keeping waste package temperatures below, say, 85°C. In particular, the Board believes that the DOE should use performance assessment to evalu-

ate a low-temperature, ventilated design concept. If necessary, performance assessment models should be modified to portray accurately the effects of temperature changes on performance. Associated levels of uncertainty in repository performance should be developed for both high- and low-temperature design concepts. The Board realizes that the DOE also may want to examine other design-related considerations, including licensability, operations and logistics, flexibility, cost, etc. The more technically defensible and quantitative the evaluation and comparison, the more useful it will be for policy-makers.

#### **D. Development of Multiple Lines of Evidence**

Although demonstrating, in a conventional sense, how a repository will behave thousands of years into the future may not be possible, steps can be taken to increase confidence in estimates of future performance. The Board has strongly endorsed the DOE's efforts to develop multiple lines of evidence supporting a safety case for the proposed repository. During 2000, a fourth iteration of Repository Safety Strategy (RSS) (CRWMS 2000) was prepared that describes a safety case for a Yucca Mountain repository.

The DOE's safety case rests on key elements, or pillars: performance-assessment calculations, safety margins and defense-in-depth, evaluation of potentially disruptive events, insights from natural analogs, and performance confirmation. In the Board's view, the pillars of the RSS do not yet satisfy the goal of providing multiple lines of evidence and therefore do not substantially increase confidence that a repository at Yucca Mountain will perform as anticipated. Some of the pillars—performance-assessment calculations, safety margins and defense-in-depth, and analyses of disruptive events—are currently presented as all dependent on performance assessment. Thus, if one lacks confidence in the DOE's performance assessment, one is not likely to have much confidence in the other pillars that depend on it. The last two pillars of the repository safety case—natural analogs and performance confirmation—are independent of performance-assessment calculations. However, the 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. The performance assessment plan should detail how any testing after repository closure would occur, including relevant monitoring activities. Additional development of multiple lines of evidence supporting the safety case of the proposed repository should be a high priority for the Yucca Mountain Project.

## **II. DOE Progress in Priority Areas**

The DOE was responsive to the Board's recommendations in 2000, and progress was evident in each of the priority areas identified by the Board.

The DOE initiated an effort to quantify conservatism and uncertainties that had not been quantified previously.

Waste package corrosion issues were to be examined in an external peer review beginning in 2001, and plans were developed for studies of fundamental corrosion mechanisms.

For its existing repository design, the DOE developed a low-temperature operating mode that can maintain repository temperatures below boiling indefinitely. (The Board remains concerned, however, that a comparison of high- and low-temperature designs is needed.)

Finally, the DOE participated in a Board meeting in April 2001 to review multiple lines of evidence for projecting repository performance, including the degree to which such lines of evidence that are independent of performance assessment can be found.

## **III. International Activities**

Since its inception, the Board has sought to increase its knowledge and understanding of the problems shared by other nations as they try to find safe ways to dispose of spent nuclear fuel and high-level radioactive waste. The knowledge gained by the Board from its interactions with those involved in other programs and with counterpart entities hav-

ing responsibilities similar to the Boards in other countries has been very valuable in enhancing the Boards bases for evaluating the scientific and technical work of the DOE at Yucca Mountain, Nevada.

The Board hosted the mayor of Oskarshamn, Sweden, and two representatives of the municipality at the Boards May 2000 meeting in Pahrump, Nevada, and at meetings in Washington, D.C. The municipality is considering whether to proceed to the third step in repository site selection under way in Sweden. The process consists of three phases. After volunteering for consideration, communities may withdraw during the first two phases. Once a community decides to move forward to phase three, however, it is indicating its willingness to serve as the permanent repository site.

In June 2000, two representatives of the Board traveled to Finland and Sweden to discuss the status of corrosion research with scientists and engineers who are working on the repository development programs of those countries. The Board delegation met with representatives of ÅF-Energikonsult AB; the Swedish Nuclear Waste Management Company (SKBa company wholly owned by Swedish nuclear utilities and responsible for all spent-fuel storage and disposal in Sweden); the Swedish Council for Nuclear Waste (KASAMthe Boards counterpart in Sweden); Posiva Oy (Finlands repository development agency); and VTT Manufacturing Technology in Helsinki.

As the time for a site recommendation decision approaches in the United States, the Board sees a continued need to benefit from the experience and work of other programs and to keep the international community informed of work here.

## **IV. Evaluation of the Boards Performance in 2000**

The Board believes that measuring its effectiveness by directly correlating improvements in the DOE program with Board actions and recommendations would be ideal. However, the Board has no implementing authority, so it cannot compel the DOE to comply with its recommendations. Consequently, a judgment about whether a specific recommendation had a positive outcome for the DOE program is, in most cases, (a) subjective and (b) an imprecise indicator of Board performance because implementation of Board recommendations by the DOE is outside the Boards direct control. Therefore, to measure its performance in a given year, the Board has developed the following performance measures for each annual performance goal.

1. Were the reviews, evaluations, and other activities undertaken under the auspices of the goal completed?
2. Were the results of the reviews, evaluations, and other Board activities communicated in a timely, understandable, and appropriate way to Congress and the Secretary of Energy?

If both measures are met, the Boards performance in meeting the annual goal will be judged effective. If only one measure is met, the Boards performance in achieving that goal will be judged minimally effective. Failing to meet either performance measure, without sufficient and compelling explanation, will result in a judgment that the Board has been ineffective in achieving that performance goal.

On the basis of these performance measures and the evaluation included in the appendices to this report, the Boards performance for fiscal year 2000 was found effective. For a more detailed discussion of the Boards evaluation, see Appendix H.

## References

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