



Department of Energy

Washington, DC 20585

October 13, 1995

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Dr. John E. Cantlon
Chairman
Nuclear Waste Technical Review Board
1100 Wilson Boulevard
Arlington, Virginia 22209

Dear Dr. Cantlon:

This letter transmits the Department of Energy's response to the Nuclear Waste Technical Review Board's *Report to the U.S. Congress and the Secretary of Energy: January to December 1994*, also referred to as the Board's *Eleventh Report*, that was issued on March 31, 1995. Our response to the Board's recommendations may be found in the enclosure.

As noted in the Board's report, the Civilian Radioactive Waste Management Program has changed significantly with the implementation of the Program Approach. We believe that the modifications already initiated and the further refinements proposed by the Department represent improvements over previous plans. We look forward to receiving the Board's specific comments and recommendations regarding these actions.

We appreciate the Board's concern with our strategies to address complex technical issues such as the waste isolation strategy for a potential repository at Yucca Mountain. We believe that the program has matured to the point where credible strategies can be presented and competently investigated. These strategies, however, represent current thinking and may change as we gain further understanding of Yucca Mountain and other aspects of the waste management system. We have made the development of these technical strategies a high priority, and we look forward to presenting the results of the efforts at an upcoming Board meeting.

The Department believes it has established a plan for adequately and dependably pursuing and funding the program's highest priority activities, including the development of near-term storage technologies and the suitability evaluation of the candidate Yucca Mountain site. We agree that the momentum of these activities should be maintained while recognizing that the implementation of this effort is contingent upon Congressional appropriations. If funding levels consistent with the Administration's Funding Proposal are not forthcoming in future years, or if policy redirection is received from Congress, it will be necessary to revise the program.

The Department appreciates the Board's constructive review and insightful recommendations regarding our technical program. We are looking forward to receiving the Board's views on the implementation of our plans supporting the program's approach as we move forward in a technically sound and cost-effective manner. If you have any questions, please contact me at (202) 586-6850.

Sincerely,



Daniel A. Dreyfus, Director

Office of Civilian Radioactive
Waste Management

Enclosure

**DOE Response to the Recommendations of
the Nuclear Waste Technical Review Board in its
Eleventh Report to the U.S. Congress and the Secretary of Energy
March 1995**

**RECOMMENDATIONS FOR STRUCTURAL GEOLOGY AND
GEOENGINEERING**

Recommendation 1:

The DOE must articulate a clear waste isolation strategy that provides an understandable technical rationale for prioritizing the studies to be completed under the new program approach.

Response:

The Department agrees that a clear waste isolation and containment strategy and a better definition of the requirements for evaluating the preclosure repository requirements for design and safety are needed. This information will also provide part of the basis for decisions about program priorities. Briefings to the Board in January and April 1995 by the Department and its Management and Operating Contractor provided preliminary thinking on the waste isolation strategy and related topics. These discussions addressed technical issues related to the components of the waste isolation strategy, approaches for resolving issues, and the relationship between the surface-based and underground exploratory studies facility-based investigations, waste isolation and related issues.

A formal description of the elements of the waste containment and isolation strategy is being developed by the Management and Operating Contractor and the U.S. Geological Survey. The description will include the elements of both the natural and the engineered barrier systems that are expected to contribute to safe performance of the site. The waste isolation strategy will consider the recently released recommendations of the National Academy of Sciences regarding environmental standards for the Yucca Mountain site. External distribution and review of this paper is expected in early Fiscal Year 1996.

Recommendation 2:

The Board recommends that the DOE carry out the minimum suite of underground exploration and associated testing outlined in its December 6, 1994, letter prior to the site-suitability decision to ensure that no major surprises will be encountered during the completion of the deferred program.

Response:

Although completion of underground exploration and associated testing is dependent upon adequate funding, no site suitability decisions will be made until the requisite scientific and engineering programs are completed. The Department's plans regarding the composition of the exploration and testing program were discussed in detail in our response to your letter of December 6, 1994, and sev-

eral subsequent presentations. These plans will evolve as information is obtained and analyzed. The resultant changes will be presented to the Board during routine meetings as they are developed and approved. If adequate funding for the requisite scientific and engineering programs is not forthcoming, the existing milestones will have to be modified or alternative milestones established.

Recommendation 3:

The DOE should develop a more efficient approach to managing the design and construction of the underground exploratory facility; this approach should include the creation of a geoengineering board of expert consultants and greater accountability and incentives for cost-effective and timely performance of the contractors.

Response:

As discussed at the July 1995 Full Board meeting in Salt Lake City, the Department plans to establish a geoengineering board of expert consultants as recommended by the Board. These consultants will provide experience in areas, such as, geotechnical engineering, construction management, project management, and tunnel boring machine design and modifications. The geoengineering board will review project design products, budgets and schedules and will provide recommendations to management.

The geoengineering board will consist of three members appointed by an executive steering group consisting of: the Yucca Mountain Site Characterization Office's Project Manager and Assistant Manager for Engineering and Field Operations; the Management and Operating Contractor's Assistant General Manager, Nevada, and the Site Construction and Operations Manager. The steering group will provide guidance to the geoengineering board, review recommendations, and direct the formation of *ad hoc* technical review groups.

With regard to greater accountability and incentives for contractors, the program is considering alternative contract structures on a case-by-case basis for each contract. Existing design and construction contracts provide incentives by linking the award fee directly to performance as measured against predetermined objectives, including timeliness and cost-effectiveness.

Recommendation 4:

The DOE should clarify the "low" thermal management strategy and its relation to the overall waste isolation strategy for the repository. Data needed to support this concept should be defined and the means of obtaining the data determined. For the program approach to be credible, the DOE also must clearly define actions that will be taken if a case cannot be made for a high thermal loading during a license amendment prior to 2008.

Response:

A thermal loading strategy is needed to focus design activities and as part of the scientific and engineering basis for evaluating compliance of the potential repository with the Department's siting guidelines and with the Nuclear Regulatory Commission's technical criteria. These compliance evaluations will rely on performance predictions for natural and engineered barrier systems under expected repository conditions. To date, computer modeling has been the primary source of information about

the effects of thermal loading on natural and engineered barrier performance. While laboratory tests and limited field tests have provided some data, measurements of repository-induced thermal effects at larger scales will initially be obtained from long-duration tests conducted in the Exploratory Studies Facility. Limited results from these long-duration tests will be available to support the 1998 technical site suitability evaluation and the license application. This situation leads to uncertainties in material performance requirements, design constraints, and overall repository performance. For example, an important uncertainty related to thermal loading is whether relatively high loadings will produce dry conditions around the waste packages and, if so, how long these dry conditions would persist. How moisture is redistributed in the environment surrounding the waste packages is key to predicting repository performance.

The proposed strategy is to focus current design activities on a reference design thermal load that will permit emplacement of at least the statutory maximum within the primary repository area and will produce dry conditions around the waste packages. This is a modification from the "low" thermal management strategy referred to in the Board's recommendation. The current working hypothesis is that an areal mass loading of 80-100 metric tons of uranium per acre will satisfy both repository loading and dry condition criteria. As a working hypothesis, the strategy will maintain prudent levels of flexibility by including alternative areal mass loadings through design options and variations in operational parameters. As laboratory and field test data become available and more refined analyses are performed, a preferred thermal load ultimately will be selected.

The evaluation of technical site suitability in 1998 will rely on assessments of preclosure and post-closure performance of the repository system for the reference design thermal load, and for alternative areal mass loadings. Similarly, the 2001 license application will present the design and performance assessment predictions for a repository system that will safely operate at the selected thermal load, as well as for the alternative loadings. For both of these milestones, the assessments will be based largely on theoretical model predictions consistent with the laboratory and field test data available at the time.

Risks associated with this strategy, such as unexpected and undesirable site responses, will be mitigated by maintaining the flexibility to accommodate a range of areal mass loadings and by pursuing a robust performance confirmation program. A lower loading may be appropriate if testing and modeling show that the negative impacts of heat dominate, such that performance of the natural system cannot be predicted with adequate confidence to meet the regulatory requirements with reasonable assurance.

The preferred thermal loading ultimately will be selected based upon evaluations of the reference design thermal load and alternative thermal loads. System studies will provide the technical basis for the thermal loading decision through evaluations that consider performance, cost, schedule, and operability. Contingency planning and risk assessment will be evaluated. The regulatory risks associated with this strategy will be managed through interactions with the Nuclear Regulatory Commission.

Recommendation 5:

Until contravening evidence becomes available, the DOE should continue to assume that the Ghost Dance Fault is "active" and capable of fault displacement within the repository block.

Response:

As described in the topical report, "Methodology to Assess Fault Displacement and Vibratory Ground Motion Hazards at Yucca Mountain" (YMP/TR-002-NP, DOE, 1994), the Department intends to assess fault displacement hazard, including the Ghost Dance Fault, using a probabilistic approach. Teams made up of experts in paleoseismology, tectonics, and seismology will use available data to develop interpretations of the activity of the Ghost Dance Fault and other faults in the controlled area and to specify the associated uncertainties. The available data will include the results of geologic mapping, paleoseismic studies, and geophysical surveys of these faults. The interpretations will include evaluations of the possibility of both primary displacement, and secondary displacement related to primary displacement on other faults in the site vicinity. The interpretations will be integrated to produce a hazard curve showing the annual probability that various levels of fault displacement will be exceeded along the faults. The results of the fault displacement hazard assessment will be used to develop seismic design inputs for the preclosure period and as input to postclosure performance assessment.

Recommendation 6:

The DOE should reevaluate its approach to seismic hazard estimation and place more emphasis on probabilistic hazard estimates and the insights they can provide to guiding the field investigations and resolution of important questions.

Response:

The Department is currently conducting a probabilistic seismic hazards assessment for a geologic repository at Yucca Mountain. DOE recognizes the potential benefit such an assessment provides by identifying important contributors to hazards and by explicitly including uncertainties. The Board's recommendation is consistent with the approach described in the topical report, "Methodology to Assess Fault Displacement and Vibratory Ground Motion Hazards at Yucca Mountain" (YMP/TR-002-NP, DOE, 1994). The topical report was prepared to document the evolution of DOE's approach to seismic hazard assessment since publication of the Site Characterization Plan (DOE, 1988). It also outlines DOE's integrated approach to seismic hazards assessment and seismic design, of which the hazard assessment methodology represents the first step.

The planning of field investigations takes into account many factors, including results of ongoing work and guidance provided by the Nuclear Regulatory Commission (e.g., NUREG-1451, NRC, 1992). For instance, results from a probabilistic assessment of ground motion hazard for the Exploratory Studies Facility have been factored into recent planning and data analyses. In particular, the major contribution of background seismicity to the hazard has highlighted the importance of the data (e.g., the seismicity catalog) that will be used to evaluate the recurrence of earthquakes for the background source.

RECOMMENDATIONS FOR HYDROGEOLOGY AND GEOCHEMISTRY

Recommendation 1:

The DOE working group on ground-water travel time should attempt to establish as early as possible the conceptual model of the unsaturated zone hydrology that it will use in the computation, so that the specific data requirements can be met at the earliest possible moment. In particular, the effort in isotopic data collection and analysis for ground-water age dating should be accelerated and expanded to increase the spatial resolution.

Response:

The Department agrees that a conceptual unsaturated-zone flow model of the site should be produced as soon as possible to focus data collection. The Department also believes that geochemical analyses and age dating will play an important role in confirming and/or calibrating the unsaturated zone model.

A three-dimensional conceptual site-scale model of the unsaturated zone is currently being calibrated using existing site data (i.e., stratigraphic, saturation, moisture tension, gas pressure, and temperature) from recent boreholes. Sensitivity analyses are being conducted that will aid in understanding the effects of geologic features and heterogeneity on unsaturated flow and will provide guidance to the site characterization program. The model is being used to make *a priori* predictions of the hydrostratigraphic conditions that are encountered in borehole UZ-7A. These predictions will be compared to the conditions encountered during drilling. The model is also being used to analyze the effects of excavation of the ramp on the pneumatic flow system.

At a more detailed level, in two dimensions, the effects of heterogeneity and the conceptual flow model are being investigated as part of the analysis of ground-water travel time. The two-dimensional cross sections through the mountain that are being modeled were selected based on results of the site-scale model (i.e., at locations expected to yield short ground-water travel times). Currently, results indicate that heterogeneity plays an important role in focusing flow into fractures and that the dual-permeability conceptual flow model may be a better representation for matrix/fracture interactions than the equivalent continuum model. In this case, the matrix/fracture interaction term remains as the largest unknown.

Data gathered during construction of the Exploratory Studies Facility (i.e., dripping fractures, moisture contents, and geochemistry of pore water and drips) will play an important role in defining the matrix/fracture interaction term for the more detailed dual-permeability flow model and in confirming and calibrating the site-scale unsaturated zone model. The geochemistry will be analyzed and isotopic age-dating analyses will be conducted on water samples from wet zones and on water extracted from core samples collected at intervals along the ramp during construction. Simulations conducted to replicate the occurrence and age of the water should aid in determining an appropriate fracture/matrix interaction term. To date, only one wet zone has been encountered. The occurrence of this wet zone, at the base of Tiva Canyon, was expected based on predictions using the site-scale model of the unsaturated zone.

Recommendation 2:

Because of the importance of the data that will be gained during underground excavation and because of the significant costs that would be incurred by further delays in construction, the Board recommends that construction of the exploratory facility not be delayed any further.

Response:

The Department agrees that important data regarding the suitability of the Yucca Mountain Site will be gained during underground excavation. The Department also recognizes the cost and schedule impacts of interrupting construction of the Exploratory Studies Facility. Under the Administration's budget proposal, underground excavation would be conducted concurrently with testing, design, and other activities. However, under reduced funding scenarios, the priority of underground excavation must be balanced against other program priorities.

RECOMMENDATIONS FOR THE ENGINEERED BARRIER SYSTEM

Recommendation 1:

In performing its "focused MGDS development" approach, the DOE must ensure that all assumptions about the repository system are clearly articulated, necessary, achievable and consistent with the current regulations.

Response:

The Board raises valid concerns regarding the inherent problems associated with making design assumptions which, as recognized by the Board, must nevertheless be made. The assumptions are revised periodically and become design requirements only after passing through an appropriate quality-controlled substantiation process. The Control Design Assumption document provides a detailed description of this process. To minimize the risks, a number of measures have been taken. These measures include requirements to justify the need and to state the rationale for the assumptions. Technical groups (e.g., Systems Engineering, Performance Assessment, Licensing, Design Engineering) review the assumptions prior to final approval.

The concerns expressed by the Board regarding a few specific assumptions will be reviewed carefully and will be considered in the course of conceptual design and assumption revisions. This review will be in the next revision of the Control Design Assumptions document, which is currently underway.

Recommendation 2:

To support waste package performance predictions, the DOE must develop a formal long-term corrosion research program plan and must support the program at an appropriate and consistent level. Failure to do so risks delaying the repository opening.

Response:

The Department has defined a long-term corrosion research program, which was described in the Scientific Investigation Plan for Metal Barrier Selection and Testing (SIP-CM-01) Rev. 2, January 31, 1995. The program was detailed in an Activity Plan for Long-Term Corrosion Studies (E-20-18(b)) Rev. 1, December 27, 1994. These detailed plans and the funding requirements were included in the program Plan. The Department recognizes the importance of this effort in supporting waste package design and performance prediction. Budgets and activities are assessed periodically to accommodate changes in program direction. The Department will evaluate the programmatic schedule impacts associated with potential funding decrements to the corrosion studies against the other program priorities.

Recommendation 3:

The Board believes that the DOE should address the issue of general repository requirements for both civilian and defense spent fuel; specific repository requirements applicable to DOE-owned spent fuel should be developed.

Response:

The Department agrees with this recommendation. The Department has taken the position that its spent nuclear fuel is authorized for geologic disposal under the Nuclear Waste Policy Act, as amended. Therefore, in June 1994 the DOE Spent Nuclear Fuel Steering Group was established. This group was formed to: recommend resolution of key issues regarding the disposal of the Department's spent nuclear fuel; support issue resolution by identifying activities required to provide the necessary data or analyses; and ensure integration between the activities of the Offices of Civilian Radioactive Waste Management and Environmental Management.

The Offices of Civilian Radioactive Waste Management and Environmental Management recognize the need to establish preliminary requirements applicable to the disposal of the Department's spent nuclear fuel in a repository. To this end, we are in the process of identifying key requirements potentially applicable to the acceptance, transportation, and disposal of this fuel. These requirements would be used by the Office of Environmental Management to assist in the near-term planning for the safe storage of this fuel at existing sites and the preparations for its ultimate disposal. Once requirements are incorporated into the program's technical requirements baseline, the program will evaluate the spent fuel as part of our design and development activities.

Recommendation 4:

The Board recommends that the DOE immediately initiate studies to determine what waste forms for Hanford's encapsulated strontium and cesium salts will be accepted for repository disposal.

Response:

The Office of Civilian Radioactive Waste Management, in collaboration with the Office of Environmental Management, is investigating the issues involved with potential disposal of encapsulated cesium (Cs) and strontium (Sr) salts in a geologic repository. The majority of the capsules are primarily Cs-137 and Sr-90 with half-lives of about 30 years. However, there are concerns about the solubility of

the residual radioactive material and its potential contribution to subsystem and total system performance in a repository that must be addressed. Various pre-processing options for Hanford's cesium and strontium capsules are being evaluated by the Office of Environmental Management. As these options mature and are more clearly defined, their impacts to repository and transportation conceptual designs and design requirements will be evaluated.

Recommendation 5:

The Board recommends that DOE's performance assessments address glass waste forms and other defense waste forms at a sufficient level of detail to assist the Office of Environmental Management as it makes decisions about waste forms and waste packages. The Board also recommends that the DOE not delay the completion of its revised total system life cycle cost estimate.

Response:

The Office of Civilian Radioactive Waste Management recognizes the need to assist the Office of Environmental Management in its decision-making process regarding the many DOE-owned fuels that may ultimately require disposal in an underground repository. The DOE Spent Nuclear Fuel Steering Group that has been established will address these waste forms, and studies have been identified to further define program needs.

The Department has performed a number of total system performance assessments. For example, Sandia National Laboratories issued "Performance Assessment of the Direct Disposal in Unsaturated Tuff of Spent Nuclear Fuel and High-Level Waste owned by the U.S. Department of Energy" (SAND 94-2563, March 1995, 3 vol) for the Office of Environmental Management. The latest formal assessment of Yucca Mountain (TSPA-1995) was completed this year. As modeling capability and material and system response information have increased, these assessments have become more detailed. Among other things, the 1995 assessment evaluates the system and subsystem compliance identified in 10 CFR Part 60 for waste packages containing spent nuclear fuel and high-level waste glass.

With regard to the status of the total system life-cycle cost estimate, the current exercise began in November 1994 and was completed in September 1995. In order to improve the level of assurance on the validity of the estimate, an Independent Cost Estimate review was performed. The final report has been sent to the Board.

RECOMMENDATIONS FOR RISK AND PERFORMANCE ANALYSIS

Recommendation 1:

The DOE needs to articulate a clear and coherent waste isolation strategy that takes into account the salient characteristics of the Yucca Mountain site, the ability and desirability of engineered barriers to enhance waste isolation, and postulated changes in the basic standard and regulations that will be used to assess the performance of the proposed repository.

Response:

As described in the response to the first recommendation in the section on Structural Geology and Geoen지니어ing, the Department agrees that a clear waste isolation and containment strategy and a better definition of the requirements for evaluating the preclosure repository requirements for design and safety are needed. This information will also provide part of the basis for decisions about program priorities. Briefings to the Board in January and April 1995 by the Department and its Management and Operating Contractor provided preliminary thinking on the waste isolation strategy and related topics. Included in those discussions were technical issues related to the components of the waste isolation strategy, approaches for resolving issues, and the relationship between the surface-based and underground exploratory studies facility-based investigations and the waste isolation and related issues.

As explained in the previous response, a formal description of the elements of the waste containment and isolation strategy is being developed by the Management and Operating Contractor and the U.S. Geological Survey. The description will include the elements of both the natural and the engineered barrier systems that are expected to contribute to safe performance of the site. External distribution and review of this paper is expected in early Fiscal Year 1996.

The issue of how to plan for changes in the repository regulatory standard has been carefully considered. The most obvious impact on the site testing program is to focus attention on the adequacy of saturated zone testing to provide the basis for dilution factors that will be needed for dose calculations. Fiscal Year 1996 and out-year planning will carry this issue as a part of the planning basis that will be updated as new information and analysis become available.

Recommendation 2:

In light of the successful completion of the 1993 round of total system performance assessments (TSPA), the Board encourages the DOE to continue its program of iterative performance assessment.

Response:

The Department concurs with the Board's observation that the last TSPA iteration (TSPA-1993) was successfully completed. DOE has embarked on the next iteration (TSPA-1995), which is intended to be of limited scope and to focus primarily on utilizing more representative models for the waste package/engineered barrier system (EBS) components of the overall system. The goals and objectives of this next iteration (especially as they relate to the waste package/EBS) were presented to the Board during the Full Board meeting in April 1995. A substantial portion of the October 1995 Full Board meeting has been allocated to discuss the results and conclusions of this next TSPA iteration.

Recommendation 3:

The DOE needs to make a management and organizational commitment to develop more systematic and effective ways of using total system performance assessment to guide site characterization and to set priorities at Yucca Mountain. The Board suggests that the DOE learn from the manner in which performance was and is being used for the WIPP in New Mexico.

Response:

The Department uses many mechanisms to guide site characterization and to set testing and design priorities, including the results of total system performance assessment. Performance assessment has been used to assist in the development of the waste containment and isolation strategy. The uncertainties in the different process-level models have been used as a basis for setting general testing priorities, as described to the Board at the January 1995 meeting. Performance assessment has been used to define process model development and testing priorities in planning guidance given to site characterization and design elements of the program for the Fiscal Year 1996 annual planning process.

The program has conducted similar sensitivity/uncertainty analyses using performance assessment as reported to the Board by the Waste Isolation Pilot Plant (WIPP) Project in New Mexico. In these analyses, the most sensitive parameter is the aqueous percolation flux and the distribution of that flux in space due to heterogeneities. However, care must be taken in directly using performance assessment results to prioritize data collection because the results are predicated on the conceptual uncertainty associated with the process level models that are the foundation of the performance assessment analyses. If the conceptual understanding is not sufficient, then it is meaningless to address parameter uncertainty. If the priorities placed on site characterization activities at WIPP are examined carefully, it becomes evident that they were driven by conceptual issues (and external peer review organizations such as the National Academy of Sciences). A case in point at WIPP is the issue of gas production affecting fluid migration and salt creep. This process was not included in early performance assessment analyses and was added based on input from external reviewers.

The Department will continue to use performance assessment analyses as one input to the planning and prioritization process. However, DOE will also continue to address other aspects of site characterization that effect the prioritization process such as irretrievable data, scientific confidence, and baseline understanding.