Department of Energy

Washington, DC 20585

December 27, 1994

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 1993,* which was issued on May 6, 1994.

As noted in the Board's report, the Civilian Radioactive Waste Management Program has changed significantly since the new Administration took office in 1993. We realize that the timing of the Board's report precluded a review of these changes; however, our response to the Board's recommendations reflects the current thinking of the Department regarding the program and its new direction. We believe that the modifications already initiated and those recently proposed by the Department represent improvements over previous plans and we look forward to receiving the Board's specific comments and recommendations regarding these actions.

We appreciate the Board's concern with our efforts to develop, and possibly implement, a multi-purpose canister-based system and its specific concerns regarding the compatibility of the canisters used for storage and transportation with disposal requirements. We have made the integration of these activities a high priority and we look forward to presenting the results of the efforts at an upcoming Board meeting. In addition, we have included performance-based specifications, which cover the disposal interface, in the recently issued Request for Proposals for multi-purpose canister design and certification.

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, it will be necessary to revise the program in consultation with Congress and our stakeholders.

The Department appreciates the Board's constructive review and recommendations regarding our technical program. We are looking forward to receiving the Board's views on the detailed plans supporting the new program 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

Department of Energy Response to the Report Released on May 6, 1994 By The Nuclear Waste Technical Review Board

Report to the U.S. Congress and the Secretary of Energy, January - December 1993

(Submitted to the NWTRB on December 27,1994)

INTRODUCTION

The Nuclear Waste Policy Amendments Act of 1987 established the Nuclear Waste Technical Review Board to evaluate the technical and scientific validity of activities undertaken by the Department of Energy in the Office of Civilian Radioactive Waste Management. The Board is required to report, not less than two times per year, to Congress and the Secretary of Energy, its findings, conclusions, and recommendations. The Board has issued ten reports to date. The Board's tenth *Report to the U.S. Congress and the Secretary of Energy,* which was released on May 6,1994, reviews the Board's conclusions and recommendations, resulting from the Board's activities primarily during the 1993 calendar year. This report included 22 technical recommendations in six broad areas: (1) transportation and systems; (2) the engineered barrier system; (3) structural geology and geoengineering; (4) risk and performance assessment; (5) the environment and public health; and (6) resolving difficult issues — climate change. These recommendations and the Department's response are presented in this report. Each recommendation is quoted verbatim from the Board's report of May 6,1994, and is followed by the response.

TRANSPORTATION AND SYSTEMS

Recommendation 1:

The Board recommends that the DOE complete the systems analysis necessary to support decisions about MPC development. This analysis should determine if the various potentials of the MPC concept can be achieved in a practicable way. It should also provide a technical basis for decisions related to MPC performance attributes and design features and for developing schedules and milestones, (page 19)

Response:

The Department believes that it has conducted appropriate systems analyses to support the decision to proceed with the multi-purpose canister (MPC) design and certification process. The results of these systems analyses are reflected in the System Requirements Documents for the Civilian Radioactive Waste Management System, the MPC System Request for Proposals, and *Volume V - MPC Supporting Studies and Reports of the Multi-Purpose Canister Implementation Program Conceptual Design Phase Report.*

The analysis for development and implementation of the MPC system was performed using a systems engineering approach as recommended by the Board. This approach is documented in *Multi-Purpose Canister System Evaluation - A Systems Engineering Approach,* a report recently issued by the

Department. This report presents information that has previously been available in a variety of reports in a logical manner so that the systems engineering approach that was used in the development of the MPC system can be clearly seen. This document has been provided to the Board.

The following systems analyses were performed in support of MPC system development decisions:

- A concept of operations was developed to set the system assumptions, parameters, and boundary conditions;
- Conceptual designs were developed for the MPC, MPC transportation cask, MPC-based Monitored Retrievable Storage facility, and Utility Transfer System;
- The logistics for the MPC system were developed based on the concept of operations and the conceptual designs for the MPC system.

These analyses provided the basis for performing the system study evaluations. Those evaluations supported the decision to proceed with the design and certification of the components of the MPC system. A number of system issues were evaluated and documented for the MPC system. They include:

- *Health and Safety Impacts Analysis for the Multi-Purpose Canister System and Alternatives Report;*
- *Mined Geologic Disposal System Multi-Purpose Canister Design Considerations Report;*
- *Life Cycle Cost Comparison for the Multi-Purpose Canister System;*
- *Regulatory Considerations Report for the Multi-Purpose Canister System;*
- *At-Reactor Dry Storage Issues Report;*
- *Stakeholder Involvement Report for the Multi-Purpose Canister System;*
- *Programmatic Risk and Contingency Analysis for the Multi-Purpose Canister System Report;*
- *Evaluation of Alternative Cask/Canister Systems Report.*

All of these systems analyses and studies are included in Volume V of the *Multi-Purpose Canister Implementation Program Conceptual Design Phase Report.*

These system studies determined that the MPC system is a viable concept and that it offers significant advantages over other alternative systems. These studies also determined that the MPC system could be developed and implemented in a practicable way at a system cost competitive with other alternatives.

To facilitate in the development of the MPC system, performance-based MPC design specifications have been developed to direct design of the components of the MPC system by private industry. These design specifications state required performance of system components, rather than prescribing specific design solutions.

The MPC system studies also indicated that a schedule could be met to have the MPC system ready for initial deployment in the 1998 timeframe. The schedule developed for MPC implementation is ambitious, but achievable provided that interim milestones are aggressively pursued. The Department met with its stakeholders including utility, regulatory, and vendor representatives to validate this schedule.

The Department will ensure that additional system studies will be performed in a timely manner to support future decisions regarding the deployment of MPCs and the Department will keep the Board informed of the status and findings of these activities.

Recommendation 2:

To avoid prematurely dropping the disposal function, the Board recommends that DOE begin to address in a technically substantive way the issue of how a true multipurpose container can evolve and be implemented given what is known today and the technology that is practical today, despite all the uncertainties associated with repository design, (page 19)

Response:

On June 3, 1994, the Department issued a Request for Proposals for designing the MPC system to support spent fuel storage, transport, and disposal. The Request for Proposals includes performance-based design procurement specifications which cover disposal interface requirements related to issues such as criticality, thermal loading, containment, and materials.

The Department recognizes that operational and regulatory environments of storage and transportation are well understood, while significant uncertainties remain with respect to disposal. The Department plans to continue to evaluate the interfaces as the disposal conditions and regulations are defined to maximize the likelihood that the MPC can serve as part of the disposal system. The interfaces between the MPC and the waste package are discussed below.

Thermal Issues:

Our analyses indicate that the global behavior ("far-field") of the repository is not affected by the MPC, regardless of the capacity and heat load of the container. The local, near-field rock temperatures are affected by the MPC heat load, although the internal details of the MPC have negligible effect upon the rock temperature. The Department recognizes that the heat output of the Large MPC challenges the drift wall rock temperatures limits. This may be mitigated through waste package spacing, or aging of the fuel prior to emplacement. These issues will continue to be addressed through the repository and waste package design efforts and the integration activities associated with MPC development.

Materials:

Long-term corrosion resistance is desirable for the materials of the MPC and is consistent with the repository requirements. The MPC material requirements have been established through interactions with the repository design staff. Under these requirements the MPC basket should have adequate corrosion resistance to outlast the spent fuel assemblies. As long as the fuel is intact, the structural support, heat transfer, and criticality control functions provided by the MPC basket are unimpaired. Subsequent to fuel failure, preliminary analyses indicate that heat transfer would not be a problem, but criticality control would still be required. Under these conditions, the Department plans to demonstrate compliance with criticality requirements through the consideration of burnup credit.

If the corrosion resistance of the MPC basket materials is determined to be inadequate when the repository becomes operational, the addition of filler materials to the MPC has been considered as an option. The most direct means of adding filler materials is to cut off the upper end of the MPC. Provisions are included in the MPC conceptual design to facilitate this contingency action. Specifically, sufficient length above the active fuel is provided to insure that the cutting operation does not damage the fuel, and a means of lifting the MPC with the upper end removed has been included to facilitate handling operations during the filling process.

Criticality:

Acceptance by the Nuclear Regulatory Commission for the consideration of fuel burnup in criticality calculations is being pursued for the demonstration of compliance with criticality requirements in transportation and disposal with MPCs. Since the Small MPC does not require the use of burnup credit for the demonstration of regulatory compliance, failure to obtain regulatory approval for the consideration of fuel burnup will not preclude use of MPCs. However, operations would be limited and the associated costs would be higher due to the lower capacity of the Small MPC.

The Department recognizes that the complex issues related to predicting the population of fission product neutron absorbers may prove difficult to resolve by 1998, and is considering contingency plans such as a less complex approach that takes credit for only the uranium depletion (and plutonium production). This form of burnup credit would be sufficient to allow use of the Large MPC for pressurized water reactor fuel in transportation. Burnup credit is not required for transportation of boiling water reactor fuel in Large MPCs. If credit for neutron absorbers contained within the MPC basket is not allowed for disposal, regulatory approval for the beneficial effect of fission product neutron absorbers would be required for disposal.

Containment:

Since the shell of the MPC is not presently considered as a containment barrier, the MPC has no effect upon the repository containment issues other than the interface requirements related to waste package performance. However, should the filler option be exercised for criticality control purposes, a cast solid filler material such as a zinc alloy could contribute to fission product retention within the disposal container.

Structural:

There are no outstanding structural issues specific to the MPC.

Shielding:

The overpacks provide the required shielding in the MPC-based system and there are no outstanding shielding issues specific to the MPC.

Operation:

The size and weight of a conceptual waste package containing an MPC has been reviewed and found acceptable for repository operations.

Conclusion:

In conclusion, the Department is continuing to address all of the technical issues regarding final disposal of the MPC. We believe that the MPC is compatible with the currently known requirements of the repository as documented in the *Multi-Purpose Canister Implementation Program Conceptual Design Phase Report*. Results of the Department's technical evaluations of repository issues will be factored into the development of the MPC System, and the evolving MPC design will be considered in the focused advanced conceptual design of the repository and waste package. The Department plans to keep the Board fully appraised of these activities and welcomes the Board's comments and recommendations.

ENGINEERED BARRIER SYSTEM

Recommendation 1:

The Department should continue and extend its examination of the assumptions used for its MPC conceptual designs, ensuring that the examination includes all of its design assumptions. The potential effects of these assumptions on waste package maximum capacity as well as on waste package performance, safety, and costs should be carefully evaluated, (page 25)

Response:

As discussed in the Department's response to the above recommendations concerning the MPC, the Department recognizes the importance of integrating the disposal requirements into the MPC development process, and conversely, examining the potential impacts of the assumptions in the MPC design in the repository and engineered barrier system development process. The MPC conceptual design and its adaptability for disposal in the potential repository continue to be evaluated as a key part of the development of the waste package and engineered barrier system. All assumptions concerning the MPC conceptual design will be examined in order to achieve a waste package utilizing the MPC that will perform satisfactorily and that can be designed, licensed, fabricated, and deployed with a high degree of safety and reliability and at the lowest reasonable cost.

Recommendation 2:

In consultation with the NRC, the DOE should change the baseline designs for the repository and the waste package to reflect current thinking, (page 25)

Response:

The Department agrees with the intent of the Board's recommendation that the current baseline conceptual designs for the repository and the engineered barrier system (which includes the waste package) should be updated to reflect the revisions to the design concepts. However, the Department believes that these updates must be controlled to ensure that the systemwide impacts of alternatives are thoroughly evaluated prior to being implemented. Therefore, the Department believes that the baseline should represent approved changes to the design concept, instead of simply representing current thinking. To this end, the Yucca Mountain Site Characterization Office is developing the revisions to the conceptual design baselines for the repository and the engineered barrier system as part of the Advanced Conceptual Design activities. To support these revisions, the Yucca Mountain Site Characterization Office is reexamining and updating the system functional analyses and developing a new concept of operations for the system. In parallel with this work, the requirements assumptions are being developed, which will be checked for consistency with the concept of operations. The revisions will include the changes to the Mined Geologic Disposal System concept such as the use of MPCs. The Advanced Conceptual Design baseline will be updated no later than fiscal year 1997 with the completion of Advanced Conceptual Design via the approved Advanced Conceptual Design Summary Report.

Recommendation 3:

The Board encourages the DOE to examine seriously the principle of extended retrievability for a geologic repository and to avoid designs and decisions that could forestall implementation of the concept, (page 26)

Response:

A Retrievability Period Systems Study is being performed to systematically evaluate the advantages and disadvantages of extended retrievability. The results of the study should provide retrieval concepts for the 10 CFR Part 60 retrieval requirements as well as for periods beyond the Nuclear Regulatory Commission's (NRC) requirements. This study should be completed in early fiscal year 1995 and will be provided to the Board when it is available.

Recommendation 4:

The DOE should develop plans for examining fillers. Even if specific filler materials are not selected until later, methods for using or retrofitting with fillers in the perhaps soon-to-be-deployed MPCs should be developed now. (page 26)

Response:

The Department agrees with the need to develop plans for fillers. The processes that are to be developed, including the potential use of filler materials, are documented in the Waste Package Engineering Development Task Plan, issued in September 1993. The Department plans to initiate testing of potential filler material during Title I design of the waste package scheduled to begin in fiscal year 1998.

As noted in response to the Board's recommendations regarding transportation and systems, specific provisions for adding filler material have been incorporated into the MPC conceptual design. These provisions were developed in consultation with the waste package design staff to ensure compatibility with the waste package concepts being considered.

Recommendation 5:

The DOE should continue to examine the role of zircaloy cladding as a barrier and should recommence and accelerate research on metal joining and nondestructive evaluation of metals and welds, (page 26)

Response:

The Department is continuing to examine the potential role of zircaloy cladding as an additional containment barrier and its potential contribution to the control of the release of radionuclides from the engineered barrier system. The reasons to expect significant cladding performance and the uncertainties in expected cladding life have been examined and were presented to the Board's Panel on the Engineered Barrier System on March 10, 1994, in Livermore, California. Some scoping experimental studies are planned to be initiated next year. These studies will be directed at narrowing the conditions under which cladding will fail in the emplacement environment.

The Department agrees that there is a need for research on metal joining and nondestructive evaluation of metals and welds. The work previously done on metal joining provided valuable basic information, but it was focused on issues associated with the waste package concepts contained in the Site Characterization Plan. Research and development activities focused on the design and fabrication of the large waste packages currently envisioned are being planned. The development work that may be needed has been defined in the Waste Package Engineering Development Task Plan issued in September 1993, and includes approaches to minimizing residual stresses, welding techniques, and methods for nondestructive evaluation of waste package integrity including the remote examination of closure welds. This work will be started when the waste package concepts and preliminary designs, including selection of materials, are further developed.

STRUCTURAL GEOLOGY AND GEOENGINEERING

Recommendation 1:

The Board continues to encourage the DOE to operate the tunnel boring machine as continuously as possible while excavating the portal-to-portal main loop. Machine operations should be delayed only to recover those data that otherwise would be irretrievably lost, (page 31)

Response:

The Department's current plans place a high priority on continuous tunnel boring machine (TBM) operations. The Department's focus on determining the technical suitability of the site in 1998, however, requires that certain data be acquired as soon as possible even though they are not considered to be "otherwise irretrievable."

To support the technical suitability evaluation, contact radial borehole tests in Alcoves 3 and 4 and the two Ghost Dance Fault exploratory drifts have been added to the schedule to be excavated during the development of the main loop. Previously, the only alcove-based testing during the main loop excavation was associated with fault properties at the Bow Ridge Fault and Drill Hole Wash structure. Development of Alcoves 3 and 4 and of the Ghost Dance Fault drifts should not delay the TBM excavation operation for more than a few weeks.

Another addition is the development of a turnout to serve as a TBM starter tunnel for a second smaller-diameter TBM. The 7.62-meter TBM will develop this 60-meter long turnout before pulling back and resuming work in the main loop. The second TBM will excavate the North Ramp Extension concurrent with main loop operations. This should not significantly delay the main loop because the facility and its utilities are designed to accommodate multiple, simultaneous excavation operations.

The Department has prioritized the excavation of the North Ramp Extension so that the heater test may be initiated as soon as possible. While the Department does not believe that significant heater test data will be required for the evaluation of site suitability, it recognizes that, due to the long-term nature of the testing, it is important to get these tests started early so that as much information as possible can be gathered in support of the initial License Application if the site is found suitable.

In summary, the Department realizes that TBM operations are expensive and that the tunneling costs can best be minimized by minimizing unnecessary delays to the TBM operation. Accordingly, the Department's places a high priority on TBM operation, and only those testing activities that either are critical to the evaluation of site suitability, are of a long-term nature, or that collect data that would be irretrievably lost if deferred will be allowed to interrupt the TBM operations. These interruptions will be minimized to the extent practicable.

Recommendation 2:

Regardless of the funding level, the program should be restructured to ensure that critical site characterization activities be funded adequately and dependably, (page 31)

Response:

As noted in the Department's response to the Board's *Letter Report to Congress and the Secretary of Energy,* which was released in February 1994, the Department agrees that critical site characterization activities need to be adequately and dependably funded. To resolve the disconnect between program funding and the expectations established by the Nuclear Waste Policy Act of 1982, as amended. The Administration has proposed an increased annual funding profile for the program over the next several years and has made it clear that this funding profile is critical to cost-effective accomplishment of the program's mission.

As was discussed with the Board on April 11, 1994, and again on July 12, 1994, the basis for the streamlining being conducted as part of the Proposed Program Approach is to focus the site characterization program on those activities that are critical to Department decisions regarding suitability and licensing. In addition, the Department will ensure that the opportunity to collect site data will not be irretrievably lost even under a level-funding program. As noted in the Department's response to the Board's letter of May 17, 1994, the detailed testing plans will be provided to the Board as they are developed. We look forward to receiving the Board's comments on these plans.

Recommendation 3:

The Board recommends that the DOE develop a contingency plan and schedule for the site-characterization project that reflects a relatively level budget. The plan should favor activities critical to determining the suitability of the site, incorporate a rigorous prioritization of activities, and encourage a greater sensitivity to cost control by the DOE and its contractors. In the event that the budget is increased, a well-defined plan will provide a good basis for expanding site-characterization efforts, *(page 31)*

Response:

The Department believes that if future funding consistent with the Administration Funding Proposal is not forthcoming, and if the outlook for program funding is consistent with historical levels, it will be necessary to revise the program in consultation with Congress and its stakeholders. As the Department presented to the Board at its Spring Full Board Meeting held April 12-13, 1994, in Reno, Nevada, the strategic planning process that led to the development of tire Proposed Program Approach, included a preliminary evaluation of various scenarios and the development of limited contingency plans. One of those scenarios (referred to as the "Level Funding Outlook") assumed that the program would receive funding similar to that which has been received over the past several years. Since the development of MPCs for interim storage would still be considered, the funds available for Yucca Mountain might be decreasing in future years as the MPC funding requirements increase. This funding profile would be insufficient to carry out the program of developing geologic disposal capability as contemplated in the Nuclear Waste Policy Act of 1982, as amended (Act).

Under this scenario, development of MPCs would continue to preserve the ability to provide MPCs to the utilities beginning in 1998. However, work at Yucca Mountain would focus solely on evaluating the technical suitability of the site as soon as possible, within the funding constraints. According to some preliminary estimates, a program based on such level funding would result in a determination of technical site suitability by the Department no earlier than 2003. This determination, however, could not support a Secretarial recommendation to the President and subsequent license application, as intended in the Act. The activities supporting the National Environmental Policy Act process, site recommendation, and preparation of the initial license application, if the site is suitable, would have to be completed in sequence.

The Department believes that the preliminary evaluation discussed above is sufficient contingency planning at this time, and a more detailed evaluation at this point, without any definitive alternative funding outlook, would not be cost-effective. However, the Department is taking a number of steps to address the Board's concerns with program management and ensure that effective cost controls are in place as site characterization activities are expanded. As the Board is aware, the Office of Civilian Radioactive Waste Management and its Yucca Mountain Site Characterization Office have completed realignments, which provide a more streamlined organization focused on the strategic goals of the program. This alignment is providing the basis for a critical review of the contractor support requirements as detailed budget and implementation planning is conducted. In addition, the independent financial and management review of the Yucca Mountain Site Characterization Office is underway and will be used to assess the effectiveness of our changes and determine the need for further actions.

Recommendation 4:

The Board recommends that the DOE consider hiring commercial drilling companies to provide the needed drilling capacity in lieu of purchasing additional LM-300 drill rigs, (page 31)

Response:

The Department recognizes the Board's concerns with the cost effectiveness of the drilling program and has taken steps to address them. The Department plans to continue implementation of a flexible downhole drilling, sampling, and testing-and-monitoring program by entering into "firm fixed price" contracts with commercial vendors where appropriate, utilizing the existing contractor with existing government equipment, and utilizing Interagency Agreements with other governmental departments.

The Department believes that its current approach will address the Board's concerns. For example, in its budget planning for the next fiscal year, the Department has not included capital expenditures for additional LM-300 drill rigs and will address its needs for increasing drilling capacity through alternative means. In the detailed planning process for Fiscal Year 1995 and the out-year plans, consideration is being given to those portions of the drilling program that are amenable to developing a well-defined work scope, schedule, and unit price elements that can be procured through "firm fixed-price contracts." However, it should be noted that some portions of the drilling program may be more suited to the contractual relationship with the project's construction contractor, Reynolds Electrical and Engineering Company, utilizing the existing LM-300 and other government-owned drilling equipment. Additionally, the Department has increased its flexibility in the development and implementation of the drilling, sampling, and testing-and-monitoring program by entering into an Interagency Agreement with the Department of Interior for specialized and short-duration drilling operations. The Department was successful with the initial operation in February of this year, and two additional short-term drilling operations should be completed this fiscal year. These drilling exercises, through the Interagency Agreement are focused, efficient, and can be arranged on relatively short notice. Nor do these drilling activities require a long-term commitment of people or equipment. The Department would appreciate receiving the Board's views on the adequacy of the current approach in addressing the Board's concerns.

RISK AND PERFORMANCE ANALYSIS

Recommendation 1:

The DOE should prepare and implement a plan to increase the quality and effectiveness in the use of expert judgment in the high-level waste program. This plan should include:

(a) establishing guidelines for the use of expert judgment in both programmatic studies and performance assessments;

(b) increased involvement of management in planning and monitoring the use of expert judgment;

(c) increased use of outside (of the DOE and its contractors) expert judgment; and

(d) development of an experience base that includes the use of expert judgment in both internal studies and those involving interaction with external groups such as the NRC. (page 35)

Response:

The Department shares the Board's interest in ensuring the effective use of expert judgment in the high-level waste program. The Department is also concerned that the use of experts, through both internal and external processes, be appropriate and cost-effective. The Department's philosophy and future plans on the use of expert judgment were presented at the November 1992 workshop on expert judgment in Albuquerque, New Mexico. The previous use of expert judgment has been clearly defined on a task-by-task basis. These activities include the Test Prioritization Task, the Calico Hills Risk Benefit Analysis, the Integrated Test Evaluation, the National Research Council's Panel on Coupled Processes, the Unsaturated Zone Hydrology Peer Review, Geophysics Peer Review, and Total System Performance Assessments, to name a few. These efforts have involved both internal Department and external experts. Currently, a panel of outside experts is evaluating the work of the volcanism task and will provide an independent assessment of the probability of future volcanism. Further use of expert judgment and guidelines for its use will continue to be defined and monitored by Department managers on a task-by-task basis.

The Department's plans for the evaluation of site suitability were presented to the Board at its Fall Full Board Meeting in Las Vegas, Nevada, which included the use of expert judgment in several ways. The Department will finalize these plans after considering the comments received from these meetings. Currently, these plans include peer reviews that will be conducted when data synthesis on a particular topic is complete such as postclosure rock characteristics, hydrology, geochemistry/transport, and others. These peer reviews will take place after internal reviews have been completed and will involve experts from outside the Department. Additional external peer reviews on selected narrowly focused topics will be necessary prior to the final peer reviews. One area in which the Department plans to conduct an external peer review in 1995 is in thermohydrologic models and their application in the testing program. As the Department approaches the technical site suitability decision, it will increasingly be making decisions as to which program and technical issues will require expert judgment as decision-aiding strategies.

The Department has developed an experience base in the use of expert judgment on various projects requiring licensing. This experience base included internal projects and those involving other groups. The Department maintains an extensive record of information on each of these projects and adds to the information base as it becomes aware of additional projects that are utilizing expert judgment in various decision-making capacities. The Department will draw on this experience base as a resource for deciding which steps of the licensing process and which issues will be addressed most effectively by the use of expert judgment.

HYDROGEOLOGY AND GEOCHEMISTRY

Recommendation 1:

The DOE should develop a more coherent plan for using total system performance assessment (TSPA) studies and related sensitivity analyses to (a) focus future source term model development and (b) guide data collection both in terms of prioritizing research and establishing when sufficient information has been obtained, (page 39)

Response:

The Department agrees and is using total system performance assessments to focus site characterization activities to the extent that the preliminary state of site characterization, waste package design and testing, and model development will allow. For example, in the most recent Total System Performance Assessment (TSPA 1993: Andrews et al. and Wilson et al., 1994), the focus was in large part on the source term. A number of specific recommendations for obtaining information needed for source term model development, were made as a result of this performance assessment and its sensitivity studies. Likewise, a number of specific recommendations were made for obtaining further site data.

The 1993 Total System Performance Assessment, with its attendant sensitivity studies, was also used to identify a number of near-field information and modeling needs and make recommendations for obtaining further site data. For example, it was found that it is still necessary to evaluate the effects of uncertain and spatially variable thermohydrologic properties of uncertain fracture-matrix conceptual models, and of uncertain thermal and hydrologic regimes as a function of time and space. As part of the 1993 Total System Performance Assessment, it was shown that it is relatively straightforward to abstract results from detailed models; but what is now required is more complete sensitivity and uncertainty analyses using the more detailed process-level models, many of which are still preliminary and under active development.

The Department believes that total system models need to be tested to see if they are capable of accurately representing the important processes identified through exercising the site-scale process-level models for flow and transport. Until this linkage has been formalized and evaluated, the Department maintains that it is premature to rigorously interpret findings based on the exercise of preliminary total system performance models. During Fiscal Year 1995, the first version of the site-scale process-level flow model will be provided to the performance assessment function for testing and abstraction. After the performance assessment models can be shown to credibly bound the results of this lower level, more detailed modeling, the Department believes that the total system performance assessment results should be interpreted in terms of how much data is enough.

Recommendation 2:

The DOE should improve its capability to model radionuclide sorption and to model fully coupled reactive transport. The DOE needs to carefully compare the merits of further development ofEQ3/6 versus adoption and further development of simpler codes, (page 39)

Response:

The Department does not plan to fully couple a code like EQ3/6 with a transport code. For this reason, a comparison currently underway is examining the sensitivities to transport results of using a code like FEHM, which utilizes a bulk Kd approach and partially coupled transport rather than accounting for individual speciation of radionuclides, versus using a code like LEHGC that accounts for discrete speciation and sorption reactions at specified sorption sites. The results of this sensitivity analysis will determine whether the Department will reconsider adding the complexity of a fully coupled reactive transport module to a code like EQ3/6; but at the present time it has no such plans.

The Board's recommendation to compare the merits of further development of EQ3/6 versus adoption and further development of simpler codes implies that EQ3/6 would be used primarily for reactive transport modeling, if the code were to be further developed. However, EQ3/6 is used by the project in many other studies, such as modeling groundwater chemistry and rock/water interactions, mineral dissolution and precipitation, and mineral reactions.

Recommendation 3:

The Board recommends that, as a high priority, the DOE begin to collect and document data on mass-transport of radionuclides in near-field materials under partially saturated conditions. These data should then be incorporated into the DOE's source term model, (page 39)

Response:

The Department agrees and has established the Integrated Testing Task for testing the behavior of radionuclides in the presence of near-field materials under elevated temperatures and under variable degrees of saturation. The results of these tests are used directly in waste package performance assessment for development of its source term models. Integrated tests employ a complexity of variables whose interdependence cannot be understood in total combination until more simplified systems and interactions are explained. For this reason, the Department has planned the integrated tests sequentially to look first at the effect of elevated temperatures on near-field transport in the absence of waste package materials, and then to add engineered materials and conditions to the natural system under a variety of repository loading conditions. The added complexity has been phased into ongoing near-field studies of simpler systems beginning in 1995 and will continue into the performance confirmation period.

ENVIRONMENT AND PUBLIC HEALTH

Recommendation 1:

The DOE should develop studies of the dynamics of the Yucca Mountain ecosystem. Studies of water, energy, or nutrient transfers within the ecosystem should be considered, as should studies of the effects of repository heat on ecosystem processes. The goal of the studies should be to identify those components of the ecosystem that are most important for ecosystem health and the components that are likely to be the most sensitive to site-characterization activities, to repository construction and operation activities, and to the long-term presence of a reposi-

lory at the site. The Department should develop one or more models of the Yucca Mountain ecosystem based on water, energy, or nutrient transfers. This synthesis should come from integrating the environmental data with the geologic and hydrologic USGS data and models. The model(s) should be used to periodically (e.g., yearly) re-evaluate and prioritize future environmental studies, (page 46)

Response:

The Department plans to initiate efforts to identify and investigate ecosystem or process models that could be used to identify components of the ecosystem that are important for ecosystem health and which are likely to be sensitive to activities at Yucca Mountain. Data that are needed for these models will be obtained from various sources, including original studies, if necessary. The Department plans to keep the Board apprised of these efforts and looks forward to future comments as to the adequacy of specific studies and analyses.

Recommendation 2:

The DOE should pursue its plans to revise its ecological study plot design. The revised design should be reviewed by a statistician experienced in this type of monitoring before the new control plots are established. The DOE should consider conducting experiments in which disturbances would be deliberately applied to study plots to provide a basis for understanding the effects of site characterization on the Yucca Mountain environment, (page 46)

Response:

The Department is revising the study design for the site characterization effects study. This revised design was presented to the Board at the March 22, 1994, meeting of its Panel on the Environment and Public Health in Las Vegas, Nevada. The new approach includes an asymmetrical design (Underwood, 1993a, 1993b) without before-and-after measures. An asymmetrical design consists of more control areas than impact areas. The design will have three sampling areas, treatment plots, near-field control plots, and far-field control plots. Time-series analysis and statistical tests for parallelism in parameter response will be used to evaluate effects of site characterization activities through time (Skalski and Robson, 1992). The new design will be evaluated by a statistician before additional plots are established. The Department would appreciate receiving the Board's views on the adequacy of this approach in addressing the Board's concerns.

In response to the Board's recommendation, the Department will consider conducting experiments to gather data on effects of site characterization activities and the effects of a possible repository since this information may be required for developing the models discussed above.

Recommendation 3:

The DOE should accelerate its development of a strategy for acquiring the technical information needed to forecast the environmental effects of a Yucca Mountain repository. For purposes of evaluating the possible linkages between environmental effects and repository performance, the strategy should include an assessment of a "worst-case" scenario involving the elimination of all vegetation on Yucca Mountain. The scoping process for development of an environmental impact statement should be started as soon as practical to identify major programmatic decisions for which a formal evaluation of environmental impacts is required, (page 46)

Response:

The Department is planning to increase the effort to evaluate the environmental effects of a repository. This effort will involve modeling that was discussed in the Department's response to the Board's first recommendation regarding the environment and public health. The possible linkages between environmental effects and repository performance will be assessed. It must be emphasized that governing legislation such as the Nuclear Waste Policy Act of 1982, as amended, the National Environmental Policy Act of 1969, and other guidelines of the U.S. Nuclear Regulatory Commission and the U.S. Environmental Protection Agency, do not require evaluation of a "worst-case" scenario.

The Department concurs on the need to start the scoping process for the repository environmental impact statement. The Department plans to issue the Notice of Intent for the repository Environmental Impact Statement and begin the scoping process in mid-1995.

RESOLVING DIFFICULT ISSUES – FUTURE CLIMATES

Recommendation 1:

The DOE needs to develop a strategy for addressing climate-related issues that is based upon their significance to repository performance rather than the ability to predict future climate alone, (page 59)

Response:

The Characterization of Future Regional Climate and Environments (Study Plan 8.3.1.5.1.6) emphasizes the importance of focusing on potential future climate scenarios that are credible and potentially the most challenging to repository performance. The Department is fully cognizant of the importance of communication and integration between this study and the needs of the hydrology and performance assessment modeling community within the Yucca Mountain Site Characterization Office, and the Department is taking actions to further ensure an integrated and directed effort. The Department recognizes the difficulty, if not the impossibility, of accurately predicting future climate behavior with present knowledge and technology, and the study has been redirected accordingly.

Recommendation 2:

Future climate states should be estimated primarily through the use of paleoclimatic and paleohydrologic data. Numerical modeling can play a supplementary, but important, role in overcoming the limitations of the paleoclimate data and estimating the likelihood of adverse climate states, (page 59)

Response:

The Department believes that numerical modeling has an important complementary role in the overall climate program, while recognizing the vital contribution of paleoclimate and paleohydrologic data and interpretations. The Department believes that future climate effects cannot be estimated entirely through the use of paleoclimate data. The inherent unpredictability of climate evolution, particularly in view of anthrogenic inputs for which there are no direct analogues in the past, increases the

uncertainty in the reliance that may be placed on the record of the past. For the purposes of estimating future climate states, the future can be expected to yield climate extremes at least as great as those reflected in the past record. Analysis of past climate states are primary tools for synthesizing potential future climate variations.

Recommendation 3:

An external expert panel made up of atmospheric scientists, paleoclimate data analysts, hydrologists and specialists from other relevant disciplines should be formed to help guide the DOE in the integrated use of data and models. The chief scientist, when appointed, should play a key role in integrating the studies and coordinating the expert panel. (page 59)

Response:

The Department supports the utilization of expert opinion in developing a scientific consensus on the impacts of potential future climate change on repository performance. The Department agrees that the chief scientist, when appointed, will play a key role in integrating the studies and coordinating the use of expert judgment and the peer review process. Acknowledged professionals in the climate community are major contributors to the climate studies, publication in peer review journals are anticipated, and participation in internationally sanctioned benchmarking efforts are planned to enhance the credibility of Department-sponsored activities. Expert opinion input to the direction of the study and interpretation of conclusions is called for in the Characterization of Future Regional Climates and Environments Study.

Recommendation 4:

The range of future climate states at Yucca Mountain should be acknowledged input to repository design, (page 59)

Response:

The Department agrees that potential future climate impacts are an essential input to repository design. Much remains to be determined through the site characterization program, however, regarding the potential impact of climate change on repository performance.

Significant uncertainty exists in the climate-generated precipitation source term, the coupling of surface precipitation to subsurface infiltration and recharge, and potential effects on waste isolation and transport processes. While this uncertainty may be mitigated through considerations such as robust waste packages and engineered barriers, repository and emplacement geometries, and thermal-loading profiles, the anticipated behavior of the natural barriers, particularly as influenced by climatic effects of hydrologic characteristics, remains a significant uncertainty and a major program focus.