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# NUCLEAR REGULATORY COMMISSION

**Title:** BRIEFING BY NUCLEAR WASTE TECHNICAL REVIEW BOARD (NWTRB) PUBLIC MEETING

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UNITED STATES OF AMERICA

NUCLEAR REGULATORY COMMISSION

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BRIEFING BY

NUCLEAR WASTE TECHNICAL REVIEW BOARD (NWTRB)

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PUBLIC MEETING

Nuclear Regulatory Commission
One White Flint North
Rockville, Maryland

Monday, March 30, 1998

The Commission met in open session, pursuant to notice, at 2:00 p.m., Shirley A. Jackson, Chairman, presiding.

COMMISSIONERS PRESENT:

SHIRLEY A. JACKSON, Chairman of the Commission
GRETA J. DICUS, Commissioner
NILS J. DIAZ, Commissioner
EDWARD McGAFFIGAN, JR., Commissioner

STAFF PRESENT AND PRESENTERS SEATED AT THE COMMISSION TABLE:

JOHN C. HOYLE, Secretary of the Commission

KAREN D. CYR, General Counsel

JARED L. COHON, Chairman, NWTRB

DEBRA S. KNOPMAN, Member, NWTRB

RICHARD R. PARIZEK, Member, NWTRB

P R O C E E D I N G S

[2:00 p.m.]

CHAIRMAN JACKSON: Good afternoon, ladies and gentlemen. This afternoon, the Commission is pleased to welcome Drs. Jared Cohon, Debra Knopman, and Richard Parizek, from the U.S. Nuclear Waste Technical Review Board.

The Board members will brief the Commission on the status of their evaluation of the technical and scientific aspects of DOE's work at the Yucca Mountain repository.

The Commission is very pleased to have the three of you here.

It has been nearly two years, namely July 30th of 1996, since the Technical Review Board last briefed the Commission about the Board's activities and its perspective on the Department of Energy's program to manage high level radioactive waste.

Much has changed in that period. I recognize that the makeup of the Board itself has changed considerably in the last couple of years, but the makeup of the Commission itself is different, and that this will be the first briefing that Commissioners McGaffigan and Diaz will have had with the Nuclear Waste Technical Review Board, and all of us have been looking forward to it.

So since the last briefing, DOE has completed the 25-foot diameter tunnel into Yucca Mountain and DOE

continues to prepare a viability assessment for determining the technical suitability of the Yucca Mountain site.

Here at the NRC, the staff is developing site-specific regulations for Yucca Mountain and continues to conduct pre-application review activities of the DOE program.

As we are all aware, Congress currently is considering legislation that could significantly alter the existing high level radioactive waste program. It is clear that that program has been and continues to be in a state of flux.

The Commission believes, therefore, that this briefing is very timely is particularly interested in receiving the views of the Nuclear Waste Technical Review Board on the state of DOE's civilian radioactive waste management program.

So unless my colleagues have any comments, Dr. Cohon, please proceed.

MR. COHON: Thank you, Chairman Jackson, Commissioners. It is a pleasure for us to be here today.

As you heard, my name is Jared Cohon. I'm the Chairman of the Nuclear Waste Technical Review Board. All of our members serve part-time and most of us have other full-time jobs, our day jobs, as it were. In my case, I'm President of Carnegie-Mellon University and my area of

technical expertise is environmental water resource systems analysis.

Accompanying me are two other Board members who will make part of our presentation today. Dr. Debra Knopman is Director of the Center for Innovation in the Environment of the Progressive Policy Institute here in Washington. Her expertise is in hydrology, environmental and natural resources policy, systems analysis, and public administration.

Dr. Richard Parizek is a Professor of Geology and Geo-Environmental Engineering at the Pennsylvania State University. His expertise is in hydrology and environmental geology.

We will pretty much stay to the remarks that we submitted to you in advance, but we may stray from them from time to time, if you will permit us to do so. We do so in the name of time, in order to save plenty of time for discussion.

As you noted, Chairman Jackson, it's been some time since we briefed the Commission and had the opportunity to meet with you. In light of that, I'd like to take a moment just to acquaint the Commissioners with who the Board is.

We were created by Congress in the 1987 amendments to the Nuclear Waste Policy Act. We were charged with

evaluating the technical and scientific aspects of DOE's high level nuclear waste management program. This includes site characterization activities at Yucca Mountain and activities relating to the packaging and transport of high level radioactive waste and spent nuclear fuel.

The Board is an independent agency within the Federal Government. We are not part of the DOE or any other agency.

The Board is authorized to have 11 members, who are nominated by the National Academy of Sciences and appointed by the President. I have served as a member since 1995 and became the Board's third chairman last year.

Drs. Knopman and Parizek were two of eight new members appointed to the Board last year. With this many new members joining the Board, as Chairman Jackson noted, we've had a very busy year playing catch-up and, I will tell you, it's been a lot of fun. This is a very active, dynamic group, a very sharp group of members that we have.

Today in our prepared remarks, as indicated in the slide, which I hope will appear -- this is a test.

[Slide.]

MR. COHON: As you can see, we want to emphasize certain things, things that we view as key developments during 1997, which will be the year that we focus on.

We will also briefly discuss our views of the

upcoming viability assessment, which we expect to be the focus of much of the Board's activities throughout 1998.

Our presentation draws heavily on the Board's 1997 summary report, which we hoped would have been delivered to you before now. Unfortunately, final editing and printing of the report have taken more time than we expected, but you should be receiving the report within the next few days.

As I mentioned, we look forward to some collegial discussion with the Commission at the conclusion of our remarks.

Let me turn now to the viability assessment, which the Chairman noted in her introduction. As you know, the DOE is required to provide to the President and Congress a viability assessment, or VA, as we will refer to it, of the Yucca Mountain site, no later than September 30 of this year.

The VAs include the four elements shown on the slide, the repository and waste package design. I want to emphasize that's both for the repository and the waste package. Total system performance assessment; a plan and a cost estimate for the remaining work required to complete a license application; and, an estimate of the cost of constructing and operating the repository in accordance with the design concept.

Much of the Board's activity during 1997 involved

preparation to review the VA, which, in light of the Board's mission, will focus on design and performance assessment, the technical issues.

In 1998, we will continue our preparation and we look forward to reviewing the VA later this year.

Let me summarize for you the Board's current views on the four components of the VA.

First of all, design. The Board believes that the design activity of the Yucca Mountain project saw several major accomplishments during 1997. They include refinement of the designs for repository surface and underground facilities and for the waste package, further integration of spent fuel owned by the DOE into disposal plans, continuing studies of criticality control issues, and improved integration of engineering and performance assessment.

There are, however, continuing needs to adopt a more robust engineered barrier system and to thoroughly explore different integrated repository and waste package designs that may offer the promise of better performance, lower costs, reduced uncertainty, or simpler operations.

Let me emphasize here, we are not criticizing the design that DOE has developed. We're simply emphasizing the importance of looking at alternatives.

With regard to repository surface facilities, these facilities would be located on an 80-acre site at the

repository's north portal and would consist of more than 15 structures and a small rail yard. These facilities would receive waste and package that waste for disposal.

Except for the final closure welds and inspections of the waste packages, the Board considers all of the technology of the repository surface facilities to be commercially demonstrated and available.

However, the Board does have some remaining concerns about the design basis, including questions about the assumed peak in placement rate, which may be unrealistically high; the possibility of transferring some waste packaging operations to nuclear power plant sites, with potential cost savings; and, the potential benefits of using multi-purpose canisters as part of the overall waste management system.

These concerns are discussed in more detail in the Board's 1997 summary report, which the Commission will be receiving shortly.

Let me turn now to the repository underground facilities. You will see on the monitors a schematic drawing of the proposed repository. Let me take you through this very quickly, just to acquaint, especially the new Commissioners, with the envisioned layout.

First, you see the repository footprint itself. That's it. Excellent. Also shown is the main access, which

is the same thing as the exploratory studies facility that the arrow is following right now. This is the tunnel that the Chairman referred to before, the 25-foot diameter tunnel that was dug, that was completed just about one year ago.

This facility, the exploratory studies facility, has been the crucial experimental facility for providing data about the mountain at the level of the repository and, in addition, as I said, it will serve as the main access, one of the main access points to the repository.

Also shown in this diagram is the proposed ECRB or, as the Board has referred to it in the past, the east-west drift. That proposed tunnel is intended to actually go through rock similar to the repository block itself to gain firsthand access to the environment in which the waste would be placed if this repository opens.

DOE is now finalizing plans and starting, I believe, the construction of that tunnel.

Finally, let me just point out the surface facilities referred to earlier, shown at the north portal, the beginning of the ESF.

By the way, this whole area is approximately 300 meters below the surface of the mountain.

Let me point out, also, that the current concept is that the emplacement drifts -- that's an emplacement drift. The idea is that as these are dug, they would be

filled with waste and as filled, they would be closed off with doors, limiting human access to them.

Let me turn now to the waste package. The referenced waste package design is a double-shelled cylinder, nearly two meters in outside diameter and five meters long, with a two-centimeter-thick inner shell of corrosion-resistant alloy C-22 and a ten-centimeter-thick outer shell of carbon steel, a corrosion allowance material.

The waste package will be emplaced on its side on pedestals in the emplacement drifts. Data obtained from the exploratory studies facilities, which you just saw on the slide before, within the last two years, clearly show that the repository will be wetter than thought as recently as just three years ago.

This discovery has triggered examination of enhancements to the existing design. Examples of such enhancements are drip shields that keep water off the packages and backfill. The Board is particularly interested in seeing studies of additional design options that might include smaller shielded waste packages, a waste package design using two corrosion-resistant materials rather than a corrosion-resistant and corrosion-allowance material, and ventilation of the repository tunnels.

The DOE is actively identifying and evaluating enhancements to the reference design. These are features

that are added to or changed in the design without altering the fundamental nature of the design itself. We recommend that the descriptions and approximate cost of enhancements be included in the VA and that their effects on long-term repository performance be included in the TSPA VA sensitivity studies.

I am pleased now to turn the presentation over to my colleague, Dr. Knopman.

MS. KNOPMAN: Let me pick up the second element of the viability assessment, which is the total system performance assessment, or TSPA. TSPA is the principal, but not the only method of evaluating the ability of the proposed repository to contain and isolate waste. It is, of course, important that we also look at solid conceptual models, good data, field work, and use the TSPA, particularly the sensitivity analyses, as a way to gain insight into the uncertainties of this program.

TSPA is essentially a predictive computational model of repository performance over time. DOE is charged with carrying out a performance assessment that emphasizes the probable behavior of the proposed repository.

This past year, DOE has devoted significance and laudable effort to achieving the goal of a credible TSPA. The emphasis on probable behaviors resulted in a division of TSPA into two parts, a base case calculation and a series of

sensitivity tests.

The base case concentrates on probable or expected performance and the sensitivity studies concentrate on what if scenarios for alternative parameters and design features and various disruptive events, such as volcanic activity and earthquakes.

Extensive workshops have increased the interaction within the program and have given the DOE substantial expert input from outside the program. These expert elicitations have brought together field and laboratory scientists, modelers, performance assessment experts from within the program on many important topics.

Some of these workshops primarily from outside the Yucca Mountain project have helped to better define the conceptual and parameter uncertainty of the elements that go into TSPA.

DOE also took an important step in 1997 by forming an external TSPA peer review panel to delve into important aspects of the TSPA VA. The Board is very encouraged by the strong and independent comments being provided by the TSPA peer review panel.

Let me turn to the third element of VA, which is the plan and cost estimates for license application.

The Board is going to focus its review on this particular element, on the plans for an estimated cost of

technical activities supporting a license application. In particular, the Board believes the data from the new ECRB program, I still want to call it the east-west crossing, and other studies, among other planned studies, are vital for the Secretary of Energy's decision on the suitability of Yucca Mountain.

This decision precedes submittal of a license application to the NRC. There are many other ongoing technical activities; for example, long-term corrosion test program, there is what is called drift scale thermal tests, and some other additional hydrological tests and wells, and in the exploratory studies facility, that also must continue to support licensing.

The Board is going to want to insure that those activities are included in the license application plan and cost estimates.

The fourth and final element of the VA is the repository cost estimate. Because the Board's purview is technical, we will confine our review largely to those aspects of the cost estimate that involve technology development.

For example, the Board would be interested in techniques, allowances, contingencies used in the cost estimate to reflect the costs of technology development and to reflect current technical or engineering uncertainties.

Another cost issue that the Board will explore is how potential enhancements to the repository design that are not part of the reference design case are handled. The Board was very pleased to learn that an independent review of the cost estimate for the mined geologic disposal system will be performed for the VA by a major U.S. engineering construction firm.

It is important that the DOE clearly define for the cost estimate reviewer the construction process and the contracting basis that will be used to construct the repository.

Let me turn now to a very brief discussion about regulations, standards, and the environmental impact statement.

During 1997, the Board reviewed and commented on two aspects of the regulatory requirements for a geologic repository; siting guidelines and DOE's interim performance measure.

With regard to the siting guidelines, in April of last year, the Board submitted comments on DOE's draft revisions of its siting guidelines. That's 10 CFR 960. In the draft revisions, the determination of whether the Yucca Mountain site is suitable for development a repository would depend no longer on several individual criteria. Instead, DOE's draft suggested that a suitability determination would

be based solely on whether the repository system's both natural and engineered barriers can meet a post-closure risk-based standard that will be specified by EPA.

In the draft revisions, DOE proposed using the TSPA methodology to support this determination. In effect, the former multiple criteria standard would be integrated and subsumed into a single performance standard.

In the Board's April letter, it indicated that the proposed revisions were, in fact, a step in the right direction, in our view, but the letter also expressed some concern that the revised guidelines might be perceived as changing the rules in the middle of the game and strengthening the fears of some that performance assessment may be manipulated to support any conclusion that's desired.

To deal with that concern, the Board offered several suggestions for strengthening the proposed revisions. One, preserve the principle of defense-in-depth; two, require that a repository system complies robustly with the standard; three, specify the level of confidence that must be reached before making a site suitability determination; four, make performance assessments transparent; and, five, use a public process to decide whether the Yucca Mountain site is suitable.

With regard to DOE's interim performance measure, the second regulatory issue that the Board commended on, in

the absence of environmental standards from EPA, the DOE has developed its own interim performance measure, and this is for DOE's own use in guiding its technical program and communicating with others about the potential performance of the repository at Yucca Mountain.

The interim performance measure will be discarded if and when EPA sets standards for Yucca Mountain. The DOE did follow the recommendations and at least take into account the recommendations of the National Research Council's '95 report, referred to as the technical basis for Yucca Mountain standards.

The DOE's interim performance measure emphasizes protection of individuals living within the vicinity of Yucca Mountain; specifically, the annual dose to an average individual in a critical group living 20 kilometers from the repository, not to exceed 25 millirems per year for 10,000 years.

Both the form of this performance measure and its level of safety are similar to many other existing radiation protection standards. With one exception, from the Board's point of view, this interim performance measure seems appropriate for DOE's use. The exception is the inclusion of children from the definition of the critical group.

The Board recommended that the DOE should estimate the disclosed likely variation in doses for alternative

candidate critical groups, characterized by different locations, ages and lifestyles. In particular, the Board suggested the potential doses to children should be compared with doses to adults within each candidate critical group.

I'll now turn to the environmental impact statement. Assuming that the site is determined to be suitable, the DOE plans for the Secretary of Energy to recommend to the President in the year 2001 that the President approve Yucca Mountain as a site for a repository, and that recommendation must be accompanied by an EIS.

Many of you know that much of the work on the EIS was deferred in 1996, a response to reduced appropriations. In 1997, DOE resumed work on the EIS in earnest.

The DOE's EIS contractor mobilized staff, familiarized them with the project, as necessary, and began to assemble and analyze the data.

In 1998, the Board will be devoting some of its time to understanding the organization and content of the EIS. In particular, the Board believes the selection and characterization of the no-action alternative is critical to the technical success of the EIS process. Indeed, the delineation of each of the alternative actions is critical to the EIS.

The Board strongly endorses development of alternative repository and waste package designs and

believes that the EIS process is an appropriate venue for exploring these alternatives.

Let me next turn to transportation. During 1997, the Board reviewed the transportation of spent nuclear fuel. The Board's review concentrated on Federal regulations governing the transportation of spent fuel, analyses of the risks of transportation, and transportation practices and experiences.

The Board reached three conclusions, which I will just quickly highlight for you now. The Board continues to believe that the risks associated with transporting spent fuel are low based on current experience. However, if there is a large increase in the scale and operational complexity, as might occur when spent fuel is shipped to a repository or an interim storage facility, a heightened safety program will be needed to maintain a good safety record.

The existing capability to transport spent fuel in the U.S. Is small and much preparatory work needs to be done before fuel can be transported in large quantities. More transportation casks with larger capacities are needed.

The transportation infrastructure at some sites will need to be upgraded to allow moving heavy loads and substantial institutional planning is needed.

Finally, the third conclusion of the Board with regard to transportation is that certain measures, such as

the use of dedicated trains and full-scale testing of casks, may enhance the perceived level of safety. Because the risks of transporting spent fuel are low based on current experience, it is unclear whether such measures would be justified solely for risk reduction, but they may increase confidence in the safety performance of the transportation system.

MR. COHON: Dr. Parizek will now continue.

MR. PARIZEK: Chairman Jackson, it's an honor to address the Commission. I am on the Board for one year and I think perhaps the new Commissioners struggle with catching up to speed on very complicated technical issues, so we share some common anxiety in this regard.

But I've been watching the progress of the Yucca Mountain project for a number of years and, off the record, there has been a considerable effort made in the last several years and the whole program has ramped up, resulting in some very exciting technical findings.

The completion of the exploratory studies facility being one point. I think many of you may have seen a film of the breaking out of the tunnel, boring machine, last April, that would be on the 25th of April. That's about a five-mile long tunnel and about 26 feet in diameter, and it took achievement to complete that goal.

As anticipated by the Board, the excavation of

this tunnel provided a wealth of anticipated and unanticipated data on the geological and hydrological character of Yucca Mountain. It was a very valuable learning opportunity for the Yucca Mountain project in performing contractor oversight, managing construction, and understanding the value of seeking independent counsel from construction industry experts.

Some of the lessons learned are listed below, one being the type of construction contract is important. Underground construction worldwide uses competitive processes, normally including fixed-price contracts. Cost-plus contracts, such as used by DOE for the ESF, have no known precedent in underground construction and probably little, if any, incentive for efficient or cost-effective construction.

Secondly, the contractor knows how to manage risks associated with equipment design and performance. So design, procurement, and disposal of construction equipment, including tunnel boring machines, are normally left to the construction contractor.

Specifications for such as the hydraulic spill mitigation, dust control and safety requirements can be defined and enforced without telling the contractor how to accomplish those objectives.

Industry expertise is important and accessible.

In 1995, they experienced several difficulties in excavating the ESF. DOE, in conjunction with the contractor, established a consulting board. This was largely through roof falls and broken rock conditions which made the startup of the tunnel difficult.

This Board was very effective in achieving improvements and the DOE is commended for involving outside expert consultants.

Large diameter tunnels are more expensive and time-consuming to construct than smaller diameter tunnels. The design for Yucca Mountain repository includes large, a 7.6 meter diameter tunneling, for service tunnels and exhaust drift. Smaller tunnels would be affected much less by the highly fractured nature of the rock. You would have less risk for rock falls and require less support, and it would be much more constructable than the large proposed tunnel.

So there have been some strong views by the Board on these issues.

The east-west tunnel is something the Board had recommended the importance of doing some years back. The Board previously recommended this excavation at an elevation at the repository level parallel to an emplacement drift, and DOE decided to place the exploratory tunnel facility above it and on a diagonal to it, in order to maximize

information with different rock units to be penetrated by the tunnel and also to provide an opportunity for doing experiments above the experimental tunnel facility that's already there.

The principal focus of this tunnel would be to obtain data to reduce the uncertainty of the hydro-geological environmental within the repository. The DOE has accepted this recommendation in general, but has expanded the scope, which is known as the enhanced characterization of repository block program, which consists of the tunnel and two bore holes to be drilled from the surface and all excavations, including three alcoves off the tunnel, will be completed by about January 1, 1999.

The next slide would be helpful in showing where the present ESF is located. You see in the diagram it's east-west orientation and you see the north ramp, comes to the point of the little round circle, having gone through the Ghost Dance Fault, and then that turns southerly and continues south parallel to the Ghost Dance Fault, before breaking back out to the mountain on the southern ramp, which you saw, I guess, the film, Breakout, pictures.

Above it, you'll notice the east-west tunnel rises up above and continues in a southwesterly direction, penetrating the Solitario Canyon Fault on the west of the block. Again, there's the importance of knowing what the

rock conditions and the hydrologic conditions are like in that repository environmental, because the original idea of maybe you would use the block to the east of the Ghost Dance Fault is not currently in the planning, as we understand it.

Notice that the emplacement drifts, the black line is located well below the east-west tunnel. The purpose here would be to give DOE a chance to do experiments, percolation type testing, to perhaps force water flow between the east-west crossing in the tunnel to understand better how water moves in the mountain.

So what we have then is this block, which, without this tunnel, you wouldn't have any idea about the faults. You don't see them at the surface, but if they're there, you need to know about this and this is one way to learn about it.

The Board supports a decision by DOE to excavate the east-west tunnel expeditiously, although the hydrological testing may not start until 1999, observations and mapping and limited data on chlorine-36, which would indicate possible flow paths for water moving through the mountain, and available -- would be available ahead of the VA.

This is important because the chlorine-36 is the main indication of fast water flow through portions of the mountain that you're familiar with.

The thermal testing program is also in an important stage right now. One of the primary functions of the ESF is to provide access to the strait in which the repository is to be located and to conduct thermal testing, especially the effects of repository heat on movement of water within highly fractured and unsaturated rock.

The data from the thermal testing will be useful for validating the various hypotheses and assumptions used in developing performance models in the current repository design.

Two tests are being conducted in ESF, a single-heater test and a drift scale test. The single-heater test has been in a cool-down phase since May 1997 and all testing was to be completed by the end of January 1998. Post-test analyses within this portion of the ESF are planned and the information should be available for incorporation in the viability assessment.

And the single-heater test is placed in the block of rock surrounded by essentially tunnels on several sides, and, again, it's a limited period and a limited heat source.

The drift scale test, on the other hand, is located in a about a 156-foot long test area and it's equipped with heaters that simulate the thermal conditions of a waste package in a repository. On December 3, 1997, the heaters were turned on and data collection was begun

from sensors in the surrounding rock mass. There are thousands of measurement opportunities that are being taken and will continue to be taken through the duration of the experiment.

The heating phase is planned to last approximately four years, with normally four years for cooling afterward. The DOE is to be really complimented and commended on implementing this extensive and important thermal testing facility. It was ahead of schedule and required a considerable effort.

The large block test is an additional thermal test being conducted on the surface near Yucca Mountain, unexcavated outcrop of welded tuft. It was designed to promote formation of reflux or heat pipe zones, as heat is applied to the bottom of a large block of fractured rock. The heat pipe is more or less the concept by which water flow returns back through a boiling zone as a water condensing somewhere up above in an emplacement drift.

Water mobilizes as vapor and then is expected to be driven out of the pores of the rock and to flow upward, where it will condense in cooler regions of the rock. The condensate then will return as reflux to the above-boiling zone.

On February 28, 1997, the heaters were turned on and the test was nearing completion at the end of 1997.

Our major concern would be what happens when radionuclides might actually reach the water table. In late 1997, the Board visited Yucca Mountain and nearby Amergosa Valley for field observations about the flow of ground water between Yucca Mountain and the Amergosa Valley region, how ground water conditions varied in the past as the climate varied and how radionuclides -- radioactive material was released to ground water might in the future enter the human biosphere through seeps or springs or withdrawal through wells.

Estimates of the concentrations of radioactive materials entering the environmental south of Yucca Mountain repository will be highly uncertain.

The saturated zone is highly fractured and faulted and caused ground water flow to be channelized or there's a chance of having sort of like a fast-path type of flow rather than kind of a diffuse mechanism of flow. So we would have this chance of having these more transmissive zones.

Within these zones, ground water movement will be faster than the average ground water flow rate through the saturated zone and retardation of radionuclides may be less than average, mixing of ground water-containing radionuclides and the radionuclide-free ground waters within the saturated zone will dilute radionuclide concentrations,

but demonstrating the degree to which mixing would occur in a channelized flow system may prove very difficult.

An important and perhaps greater source of dilution may be mixing at a well head or a spring, where ground water leaves an aquifer and enters the biosphere. This depends on the specifics of the well withdrawal. Dilution by flow and transport in the saturated zone is difficult to quantify because of its significance in determining the relevant importance of different factors affecting dilution and an early definition of well withdrawal scenarios could provide an important focus for studies at Yucca Mountain.

The fate of radionuclides after the end of the biosphere and as they enter food chains and potentially cause radiation doses to humans must be projected. The use of generic data and models of the transfer of radionuclides through the food chains may cause large uncertainties in estimating radiation doses, perhaps as much as three or four orders of magnitude.

Part of this is the specific nature of conditions at the site. With that climate, it may make the pickup of radionuclides different than what might appear in the standard data tables that support this.

Thank you.

MR. COHON: Thank you, Dr. Parizek. I have one

last issue that I would like to cover in our prepared statement, and that is the use of experts from outside of the DOE, an important topic, we think, and one that we know that the NRC has focused on in the past.

The DOE is to be commended, as you heard already, especially from Dr. Knopman, in their stepped-up and effective use of experts from outside of DOE.

They have two very important standing panels that they have used extensively; the TSPA peer review panel, which has been very active recently, and the mine geologic disposal system consulting board, which has been very effective, first, in the completion of the ESF and, more recently, in planning for the ECRB.

In addition, the DOE has become more active and very extensively so in the last two or three years in the use of experts who are not part of one of these existing panels, but from whom opinions are sought in a formal process.

This seems to have worked very well. We, the Board, consider this to be an important activity for DOE, especially in areas where there is great uncertainty, which is to say much of what they're working on in Yucca Mountain, and before all of the relevant data can be in hand, which is also much of what they're working on at Yucca Mountain.

Some notable examples of successful application of

successful use of outside experts are in estimating seismic and volcanic hazards, unsaturated zone and saturated zone flow, and waste package degradation.

The Board has pointed out and I want to emphasize today that there are continuing issues that the DOE must deal with in the use of these outside experts. In particular, we remain concerned about those situations where there are very few experts and those experts sharply disagree. This is a difficult problem, certainly not unique to DOE's use of experts or, of course, to Yucca Mountain, but nevertheless a problem that must be dealt with if their information is to be used effectively.

Let me conclude by saying that, as I said at the beginning, this has been a very busy and eventful year, both for the Board and for the program at DOE, and, if anything, the future seems even more eventful, as we look forward.

As we know, the VA will be issued later this year, a time when the Board will be expected to comment, and that will be a key milestone as DOE moves to siteability determination approximately in the year 2001 and all that comes after that.

That concludes our remarks. We look forward to your questions. Thank you, Chairman.

CHAIRMAN JACKSON: Thank you. Let me begin by asking you a couple of questions and I'm going to wade right

in to a couple of quasi-controversial topics.

Given what you talked about vis-à-vis the possibility or likelihood of channelized flow, with possibly limiting dilution and retardation, possible dilution as the water is withdrawn, perhaps via well, does the Board have a view on what that might -- whether that necessitates having a separate ground water protection standard?

MR. COHON: You did say you wanted to get right to controversial issues.

CHAIRMAN JACKSON: Right.

MR. COHON: And congratulations, Chairman Jackson, you did just that. Do either of my colleagues want to take this one to start?

MS. KNOPMAN: Why don't you start?

MR. COHON: Now we know it's controversial. They refused.

Indeed, this a very sensitive topic, sensitive in the sense of having big impact on the estimates for probable doses. As the Chairman pointed out, there are two key ways in which dilution may occur. One is in the saturated zone that is below the water table after the waste migrates to that point and then when the water is withdrawn. Dr. Parizek referred to these, as well.

On the first point, while we have heard what we have listened to the experts say, and this was a case where

DOE appealed to outside experts and they had superb people, by the way, on their expert panel. Where the experts felt there was considerable uncertainty about the effect of dilution in the saturated zone, that, if anything, they felt it was more probable that significance dilution would not occur. Channelization would occur, as you said.

That we should expect the plume to stay fairly much intact rather than spreading out greatly. That's their expectation.

Dilution at a well head offers -- could be very large. I guess the big difficulty here is whether one can count on that. It is possible to sink a well and take water just from one strata and, therefore, get no dilution, no significance dilution. That may be a low probability event, but it's possible. I think the key question, of course, will be, as the Chairman put it, what the standard says.

Now, colleagues, do you want to expand or subtract from what I said?

MS. KNOPMAN: No. You did an excellent job. I would just add that in thinking about these different well withdrawal scenarios, you could get the substantially different result if you were, say, looking at a well field rather than an individual well and you were looking at total pumping rate from a well field, let's say a water company, and then the mixing of all those waters prior to delivery to

the population.

That would produce a different, substantially different dilution than what would get from looking simply at single-well withdrawals that either may intercept multiple layers, in which case you could get substantial dilution, or a single layer at a direct hit rate into the center line of a plume.

So there is tremendous variation within the well withdrawal scenarios from the kind of result that you might -- the kind of dose that you might be delivering to the population.

MR. PARIZEK: I have a feeling that the ground water is a part of a system and even if you didn't want to take any credit for the ground water system by saying nothing can be released to the water table below the site, you lose some sense of reality.

Materials in time do reach the water table. There can be some forgiveness there. There are faults and there are fracture zones, but not all of the rock mass is necessarily that way and a certain amount of the flow paths from the unsaturated zone reach the rock mass below and there would be a tie-up or hold-back of some portion of the water.

The question is what percentage of that would be in the diffuse part of the system and what portion in the

fast-path part.

So the idea is that there would be some retardation. There is bound to be some diffusion and matrix diffusion from the fracture zones and fault zones, and there could be benefit.

There is also alluvium, which is present to the south of the site, the exact location of where the saturated zone alluvium versus bedrock occurs. It's not too well known. It's an area generally of data deficiency. But alluvium would give us a slowing down of the flow rates, much higher chance for retardation than might be possible in the fractured rock. So there's benefits to be received there.

On the other hand, to say that you will base all of it on dilution to protect the human health, maybe at that point, if dilution of the well head is your last part of the calculation perhaps, you hit some credit, but it makes a difference whether there's one well or groups of wells or a large well field. That's a future that may be a little bit hard to characterize.

So I say you should give some credit to the ground water system. More can be learned about the ground water system and more is underway to be learned about it by some of the deep drilling that's being planned, is underway at the Yucca Mountain site.

CHAIRMAN JACKSON: Are you looking at or do you feel that DOE needs to look at, for lack of a better terminology, whether it makes any sense to talk about institutionally controlled use in design?

MR. COHON: Institutional control of the water, is that what you're talking about?

CHAIRMAN JACKSON: Let me make sure I make myself clear. Just as you talk about engineered barriers, you raised -- you said the key question is what the standard says, but leading up to that, can one count on dilution at the well head and there is one way one could answer that within the context of -- or try to answer it probably using expert opinion or judgment.

There is one way one can try to get at that vis-à-vis coming at some best estimate of what the natural environmental would allow or suggest and to what extent one could make some predictive statement down the line.

The second part of it that this flows into, but not unlike the whole issue of engineered barriers is to what extent can one -- or does it make sense to talk along that line, design in institutional controls? Because if you're talking looking down the line, the issue of institutional controls in terms of organized society is something that you can't talk about.

MR. COHON: Right. Chairman Jackson, I remember

vividly appearing at the House hearing on the legislation, on a panel with you, and a member of the committee asked the question that was not unlike this, though he was looking in the future.

He was talking about human intrusion into the repository, which has always been a very difficult issue to deal with. And what I said then, which I'm not sure if it came back to haunt me or not, but it still might, was that based on the study by the other NRC, that we basically considered those kinds of issues not tractable or not ponderable, things that were beyond us.

Now, I wonder if the issue the Chairman has raised would fall under that. Can one say with any confidence that if water is developed a thousand years from now, it will be managed by a water company managing a whole well field and, therefore, getting maximum benefit from doing that, if there is any contamination. I don't know.

MS. KNOPMAN: The Board is agnostic at this point as to whether well withdrawal is the appropriate one to use in the regulatory context. Our concern is the predictive capability of the models that might be used as a basis for making any further predictions about the dilution at the well head and right now the models, saturated zone modeling effort is -- also pardon the pun -- in flux and is not at a point where there really is stability in its predictive

capability.

So that's where our concern is right now as to how to improve that capability.

CHAIRMAN JACKSON: Because I think you hit it on a few sentences ago, and that is, you know, what is appropriate or what do you need to decide what is appropriate in a regulatory context, because that's kind of where the rubber meets the road for us.

Let me go on and ask controversial question area number two. I had a question for you which went like this; to what extent is the DOE program focused on the most important issues related to the overall performance of the repository? And, of course, so as to have full disclosure, you mentioned things like the various thermal tests and, related to that, hydrologic studies.

In fact, I've just happened in the past couple of months to be out and I've looked at the large block path heater, the drift heated test and so forth.

But the real question becomes -- we, of course, have this -- and I don't mean for you to give a definitive answer. I'm more interested in where your thinking is going.

Were you surprised by the article in Science and what it suggests about the volcanism and to what extent do you feel DOE is giving attention in that area and has your

opinion in that regard changed vis-à-vis the recent Science Journal article?

MR. COHON: Let me say, first of all, as a general matter, that I believe the program right now is much more focused and effectively so than it was just two years ago and much, much more than it was five years ago, as it should be.

I think DOE deserves a lot of credit for having been able to go from basically a science program to something really focused on the question, is this site suitable. I think we need to keep that in mind.

As a Board, we have been asking ourselves just this question, Chairman Jackson; that is, how much more should the program be focused, recognizing that if the program sticks to schedule, there's really very little time left between now and the point where they are likely to recommend to the President that the site be found suitable, and then come to you to apply for a license.

In light of that, the DOE needs to be very efficient and use its very limited resources in the most efficient and effective way possible.

We are, within the Board and working with DOE, trying to develop our own understanding of what that might be, how much more focused can the program become, and the key here, of course, is identifying the key uncertainties

that will remain after VA and to focus resources on resolving those uncertainties that can be resolved or can be reduced. Resolving them is probably too strong a word, but can be significantly reduced between VA in the time that suitability is determined.

We are not surprised to here about -- we are not surprised by the Science article. We've been aware of that research for some time and have been tracking it. We may be a little more surprised by the press reports of the Science article, which is, of course, a different matter.

CHAIRMAN JACKSON: Come work with us. You get a lot of press reports.

MR. COHON: That's right. Now, I don't have the exact date, but I believe that there is a meeting coming up in the next month or so. Does someone know, offhand?

MS. KNOPMAN: Seismic hazard assessment.

MR. COHON: I'm sorry. But there is a meeting coming up where this will be looked at more carefully.

In particular, understanding the uncertainties associated with the data itself that's reported on in Science and then trying to understand what the implications of that might be for seismicity or other activity.

MS. KNOPMAN: Can I just add a little bit to that?

CHAIRMAN JACKSON: Please.

MS. KNOPMAN: This is an area of the seismic and

volcanic hazards where DOE did seek out outside experts and it's been -- that group has been meeting for quite some time and, in fact, probably did better at coming to closure than some of the other groups. So I don't think this was a surprise to the program.

You raised the question about what's important here and how does -- is the program focusing on what's important, and the Board, just to give you a flavor of where the Board's thinking is.

When you get right down to it, what we're talking -- what we're most interested in is what the near-field environmental is for those waste packages, and that means understanding the water, water flow in and out, and what's happening in terms of the conditions in which the canisters are going to be subjected.

I think the program has, because of the use of the outside experts, there is actually a specific panel, expert elicitation panel that's been convened specifically on the near-field environmental and I think the department is getting to that focus and that's also, I think, one of the indicators of how TSPA can be used productively to get through sensitivity analyses, to get to the heart of what's really driving the system.

So I think they're getting there.

MR. PARIZEK: I would say the same. DOE has

received a lot of recommendations for the need of follow-up studies to reduce uncertainty in time for, say, an LA and this list comes from the expert station panels, it comes from the NRC through the interaction that you have with DOE, and it also comes from the Board.

The key thing is not to let those programs die just because it looks like a shopping list for more science. And if you had asked the program ten years ago what was a good list, it would have been a long list. Today it's a much more focused list, but it's an urgent list.

And to come before a Commission with a license application, I maintain you have to have good science and good engineering to justify your recommendations. Otherwise, you will perhaps deny and there will be delays in the program and credibility shrinks.

I think it's quite urgent to make sure we track the remaining the studies that must be conducted, make sure that they are conducted, and funding is provided to see this through. Congress has cut the program, but you can't cut it very much more before the science may drop. And this has to do with material science, the new areas that are being talked about.

There is a short period of record there. Judges often feel insecure about our record, but we have analogs, natural analogs to draw from. The materials people maybe

lack some of that same sort of thing. So this experimentation has to be done on the corrosion processes and better understand that whole thing, because we put a lot of faith on a robust barrier, the engineered barrier, but we got to make sure it's going to work.

So I think keep the science alive and the engineering work going right to the LA deadline.

CHAIRMAN JACKSON: I'll make a comment in lieu of a question. I remember when I visited Yucca Mountain two years ago and then, of course, I've visited again more recently, there was a concern here on the science and the issue is how do you keep the focus in the right technical areas, but integrating them so it's not just a giant, multi-part research program as opposed to one that has the appropriate program integration, driving to understanding the features most important to repository operation and safety.

And so the question -- so I assume that that's something that the Board keeps a focus on.

So let me just ask one last question and then I'm going to turn it over to my colleagues.

I note that the Board has urged DOE to consider including alternative design concepts into the viability assessment, and you mentioned that in your remarks.

The question is, do you know if the DOE is doing

this and what level of detail are you really looking to see in the viability assessment with respect to this?

MR. COHON: We believe they are. Well, we know they are. They are looking at alternative designs. We do not believe that they need to be looked at in great detail or developed in great detail for the VA. In fact, it probably is not a good idea, given the limited time and limited resources, and they do need to develop the reference design, the base case as fully as possible.

Our strong recommendation that they consider alternatives is so that thinking about the limited time that remains after VA, if we stick to schedule, we fear that the program might be get locked into a particular design and find it difficult to think outside of the box of that particular design.

That's why we have been pushing alternatives so hard.

CHAIRMAN JACKSON: All right.

MR. COHON: There are also EIS implications potentially as well.

CHAIRMAN JACKSON: That's right. Commissioner Dicus.

COMMISSIONER DICUS: You mentioned the TSPA peer review panel that DOE formed last year and I think you mentioned that you were encouraged by the rather strong

independent comments that were coming from that panel.

Could you characterize those just a little bit more, particularly more significant comments regarding the TSPA?

MS. KNOPMAN: As you know, the TSPA is a -- takes results that have been generated from fairly complex physical models, mathematical models representing physical processes, and so the TSPA modeling process is but another level of abstraction from the underlying mathematical modeling. And there is a lot that can -- there is a lot going on there, a lot of assumptions embedded in that.

The concern of the peer review group has been as it has been for the Board, is how much -- by the time you get to TSPA, results have been grounded in reality, with real data and some kind of field experience to really back that up.

So the peer review panel, the TSPA peer review panel went into some depth about concerns of lack of data and justification for using certain model forms in TSPA.

I don't know if you want to elaborate on that.

MR. PARIZEK: It continues, I think, with Chairman Jackson's comment about the focus. I think when you run a TSPA and sees what seems to drive a system, the so-called sensitivity analysis part of the what-ifs part, you begin seeing what are the critical portions of the system that

need further work, like the climate effects.

Clearly, that's a driving variable. So one has to deal with that. If corrosion is one, you've got to deal with that. So whatever the outcome of this next go-around is that's issued this fall, you will have a clearer picture of where the study needs are.

The question is can you fill the gaps in the time period between then and LA. In terms of like reaching the ground water modeling, there are vast areas of areas south of Yucca Mountain with no well control. As a result, it is somewhat speculative exactly what rocks are -- hydrological conditions occur there.

And then the question is how much credit would you want to assign to the ground water rule anyhow. Maybe you can get a lot more credit out of a canister and say go with the canister part. But all of these pieces have to somehow fit together and I think when you're running the TSPA, you begin finding out how much credit you can get for each part of it as we understand at this point in time.

CHAIRMAN JACKSON: So you're thinking of the TSPA itself as a manager.

MR. PARIZEK: Yes, it is. It's a question of whether the managers now use it that way, which was your question. The program seems to have gotten more focused in recent years than it used to be in terms of grabbing onto

critical parts of the story, as I see it.

Again, maybe I've missed the point, but TSPA is an education to all of us and you can't tell what the outcome is going to be until you finally run it and then it has uncertainties with it. So what we want is to make sure we can shore up all of the areas where you don't feel comfortable, make sure the next go-around is going to be as thorough and complete as it can be.

A lot has been learned at Yucca Mountain since the early days of that program and, again, there is ramping up at a rapid rate. There is very good information coming in that we wouldn't have had only a few years ago, part of it with the tunnels, part of it with experiments that are coming to maturity.

COMMISSIONER DICUS: Let me ask you a process question, too. Given the fact that the Board has 11 members and you have somewhat similar and also maybe differing expertise, but how -- it's sort of a question about how you arrive at your decisions, but more importantly, how have you handled divergent opinions and how will those come forward?

MR. COHON: Well, it's not a very pretty sight, Commissioner Dicus.

COMMISSIONER DICUS: Like sausage being made.

MR. COHON: That's right. I didn't say that, but you did. We -- the Board works hard to attain consensus on

all major issues, all major positions that the Board adopts and before we communicate that to DOE.

We will vote on occasion, vote for our record, which is to say the public record, but generally we are able to reach consensus, and that means a lot of compromise and discussion about wording and positions about things.

Our meetings can get long. They are usually not very contentious. It's quite a remarkable collection of people. They are very, very good at working together and seeking that common ground.

I think, based on some recent meetings we've had which could have been very contentious given the issues we were discussing, that the Board -- the individual members enjoy interacting with each other very much and realize that they learn a great deal from that.

Let me correct one possible misconception. You happen to be looking at the three people with some water in their backgrounds. The other eight members don't. So, in fact, we're quite diverse in our backgrounds and what we bring to the Board, and that helps, as well. So we learn a great deal from each other because they are experts in something I'm not, and we listen carefully to each other, learn, and then generally arrive at consensus.

So far, so good.

MR. PARIZEK: Could I add a remark? And that's

the role of the staff. It is a very dedicated, very competent staff that keeps an awful lot of this history going for us, because as new members coming in, there is no way you can get up to speed on all these activities. All the expert panel meetings, usually three of them for each panel, many panels, you can't monitor those activities and keep track of the literature and so on.

So the staff brings an awful lot to the table to help get us into an understanding of the issues. That doesn't mean that we buy off on that, but at least it sets it up for us in a way that we're not having to start from ground zero and trying to invent all of this material ourselves.

With that, it would be almost impossible because we all have other full-time jobs and there's not enough of us to get this job done, the Commission knows the problem of having a limited number of people with a big assignment.

MR. COHON: Just to pick up on one thing that Dr. Parizek just said, because it will help understanding our process. He made reference to panels. The Board organized -- organizes itself into five panels, each with five Board members on it, and these are panels that are devoted to specific aspects of the repository problems.

Those panels generally take on the leadership on particular issues and do the work outside of our Board

meetings and then inform the rest of the Board members when we come back together.

CHAIRMAN JACKSON: Commissioner Diaz.

COMMISSIONER DIAZ: I'd like to say that I have maintained a very open mind on the issues of Yucca Mountain by staying ignorant about it and for having a very wide gradient between ignorance and expertise when we get to doing stuff.

But I was listening to you and was interested in the drift between science and application and, of course, science never ends and sometimes we like to keep it going. But scientific applications have to end and, in this case, there are some particular date lines and deadlines that have to apply and then closure to the VA is important and closure to the LA is important.

Thinking on the terms that scientific applications, engineering and technology and they have to be closed, do you see any show-stoppers for actually preventing this repository to becoming reality?

MR. COHON: No. I don't believe the Board has seen any show-stoppers.

COMMISSIONER DIAZ: All right. Going back now and retreating to the fact that I am more of an engineer than anything else, going back to the engineered barriers, I was particularly interested in the Board interest in the

engineered barriers.

There are essentially three issues; small waste packages, waste packages with two corrosion-resistant, and ventilation of the repository tunnel. I was having a problem fitting these things together.

When you actually make smaller packages, you increase the surface significantly, which gives you an additional potential corrosion problem, and, of course, it increases cost.

It might be better and easier to handle, but it's certainly an issue. I don't see how it combines by putting two corrosion-resistant materials in the package because if you tried to make them smaller, then that becomes more of a problem. You are actually increasing the actual cost of it.

Of course, I guess ventilation of the tunnel is because you're trying to get humidity out of it?

MR. COHON: Exactly right.

COMMISSIONER DIAZ: But that also increases some of the other issues that are -- and I'm very ignorant about this, but you know we always worried when things have higher temperature and places with higher temperatures tend to carry materials away to the lower temperatures.

I was wondering whether isolation was part of the design. So I was having a little problem in looking at the three of them interacting together, especially looking at

closure, resources, and the conditions that were to be specified.

MR. COHON: You should come and spend some time with the Board. We would enjoy it very much. This is exactly the kind of thing we hope that DOE will take on.

COMMISSIONER DIAZ: I see.

MR. COHON: And the key is to view the system as a system. Now, in this case, these three alternatives that we identified that you picked up on are distinct from each other. We're not saying smaller packages and two corrosion-resistant and ventilation. These are just three separate, but if you did them all, obviously, interacting, things one might try.

Your analysis of each is very good. But let me put out one thing that might help you because you're new to Yucca Mountain and we're happy for you being new to Yucca Mountain.

The whole idea, water is the big issue, as you heard and as you know. Water is the big issue because of the impact on the waste packages. So the argument for ventilation is to keep the tunnels and emplacement drifts as dry as possible for as long as possible, so as to the reduce the probability of corrosion. That's the whole argument.

So it's the life of the package which is driving this and that's related to water.

COMMISSIONER DIAZ: But I have a problem, and I'm not a water expert, but every time you remove water, you're actually increasing some process in looking at pressure and now you're decreasing the pressure, so you're attracting more water, if the water is getting there.

Sometimes what we'd want to do is we'd want to keep the concentration high. I don't know --

MR. COHON: This is the key point that I want to make. There is an assumption -- not an assumption. There is -- the way we understand the problem, and that's the big we, not just the Board, is that the key thing is keeping those packages intact as long as possible.

So the issue is not -- during the first part of the life of this repository, the issue is not so much migration of waste away from the tunnels, but rather keeping those packages intact because if they're intact, you don't have anything to worry about.

So that's the idea. That's what drives it all. So we're not so worried early on about gradients that are created because we're assuming that the packages will be intact and, therefore, nothing is going to be moving -- no waste will be moving out of the drifts anyhow.

COMMISSIONER DIAZ: Water will be moving in. That's why we got three water experts today.

MR. COHON: That's the whole purpose of these

thermal tests. Do you want to say something about that?

MR. PARIZEK: The whole idea of of a hot waste package if you go with a hot repository is it boils the water out and does so for a prolonged period of time. Part of the problem is where does the water go you boil out. It's going to condense somewhere and will want to come back to haunt you, perhaps right back in some of the emplacement drifts.

So as an example, getting on with the engineering decision, if you can't decide and the experiments can't be run long enough to know what happens to this refluxed water, the choice might be to consider an alternative design, as suggested by the Board, have a cold repository, in which case you don't have to deal with this reflecting issue.

Maybe you won't solve that problem, but, nevertheless, right now, if you go into Yucca Mountain, you never did see a drop of water falling in one you any place. That doesn't mean it might not be doing that, because you have the chlorine-36 data showing that somewhere in the last 50 years water got to those depths, but the fact that it's ventilated means that it keeps it dry.

Under the present environment, you could sit in there and not rust yourself, I suppose, for some number of years. We haven't had as much time as possible into the future, when the canister hasn't yet been asked to do

anything. It's sitting there waiting for the first arrival of water, sometime in the distant future.

And the moisture would be driven out because of the heat source that the warmer packages or the hot packages bring into the mountain.

So that was part of the idea of the ventilation concept. Again, if it doesn't calculate out to be suitable, you might drop it from the thinking. But right now it would buy time for canisters, and that's part of the game -- get the longest life you can out of your waste package before it has to finally resist a corrosion problem.

CHAIRMAN JACKSON: Thank you. Commissioner McGaffigan.

COMMISSIONER McGAFFIGAN: I'm going to go back to the Chairman's first line of questioning just for a little bit. On page 7 of your statement, there was a -- you talked about them being on the right track with their siting guidelines and meeting a post-closure risk-based standard, but then you put some provisos in and one was that you require the repository system complies robustly with the standard.

Can you define the adverb "robustly?"

MS. KNOPMAN: We're working on that.

COMMISSIONER McGAFFIGAN: I mean, I can turn a 25-millirem standard into a .25 millirem standard as

robustly, that means a factor of a hundred, or does robustly mean a factor of 20 percent. In order of magnitude, do you know what robustly means?

MR. COHON: No. We have not quantified it and I don't know that it's quantifiable until the standard is quantified and we have an understanding, in a quantitative sense, of the uncertainties surrounding it.

COMMISSIONER McGAFFIGAN: That's the great -- let's stay on that thought. At the moment, they're working, as you say later on that page, on a 25 millirem all pathways standard, which is to an average member of a critical group, and I think ICRP recently suggested 30, but 30 and 25 are essentially equivalent, especially if we're dealing with adverbs like robustly.

But if you hypothesize -- I don't know how much the group is familiar with WIPP and whether you've looked at the WIPP situation, but at WIPP, the EPA has a standard that includes a ground water MCL standard and it's been salt and it's been stable for 250 million years and it's probably going to be stable for 250 million more. So WIPP will pass whatever standard is imposed, I suspect.

But have you done any thinking about an MCL standard which, using the current MCLs, which are not risk-based and which go as low as .06 millirem for strontium-90, et cetera, have you looked at whether Yucca

Mountain could possibly pass robustly a standard that included ground water MCLs?

MR. COHON: No. We talk about this all the time, but it's -- I'm not sure -- well, I better be careful about going too far with this. What I'm about to say is one person's view. I am not speaking for the Board here, but 1/11th of the Board.

I think it's really too soon to say whether Yucca Mountain could meet a ground water standard robustly, even without a definition of the word robust, and I say that because we're still trying to understand what the uncertainties are. I think we now know what the key uncertainties are; that is, where they will come from.

But I don't think we know yet -- I don't know yet, maybe DOE knows now, how big those are.

COMMISSIONER McGAFFIGAN: That's my next question. Later, on page 12, you say those uncertainties could be three to four orders of magnitude.

MR. COHON: Yes.

COMMISSIONER McGAFFIGAN: So if I'm now dealing with something -- and let's say we're going to be robustly trying to meet a standard and conservative with defense-in-depth is another principle. And I add all that up, I may now have a .001 millirem standard for ground water.

De facto, can Yucca Mountain -- can a non-salt formation meet that sort of standard?

MR. COHON: Time will tell. Do I think salt is more robust? Yes. Do I think WIPP is more robust? Yes. But that's with still not mature knowledge about Yucca Mountain. We still have a way to go. I don't think we'll know at VA, again, one person's opinion.

COMMISSIONER McGAFFIGAN: Could DOE even do the calculations required at this point, given that they've been focused on the 25 millirem all pathways standard in time for VA, if EPA were to propound a standard not dissimilar from WIPP's standard?

MR. COHON: Could DOE do the calculations?

COMMISSIONER McGAFFIGAN: Could they do the calculations?

MR. COHON: Sure.

COMMISSIONER McGAFFIGAN: With dealing with all these uncertainties?

MR. COHON: Yes. TSPA could do that now.

MS. KNOPMAN: You need to show them uncertainty.

MR. COHON: Exactly right. They key thing would be what the uncertainty related with that, what that demonstration would be. That's where we come back to robustly. That's why we used the word. We know it's vague, but we think it captures the key point here.

I think the Board feels confident that you could show the repository to meet a standard of the sort that we expect will come out, but the key question will be the uncertainty surrounding that, the uncertainty surrounding the probability with which the standard will be met. If I said that right.

MR. PARIZEK: Could I have a clarification of whether you're saying at the repository, below the footprint?

COMMISSIONER McGAFFIGAN: I'll take 20 kilometers. At the repository, at the footprint, I would assume it's absolutely hopeless.

MR. PARIZEK: I didn't know where your fence, because certainly WIPP is not a good example for us to be emulating. You've got the Bell Canyon, which has got a brine that nobody wants to drink and it's got two dolomites, which have salty water right above the repository. Nobody really almost wants to drink. Some people say they have used that water. So that's a little bit different; the water could be there, but nobody drinking it.

Your question is whether you could get anything to those aquifers, even if you could.

MR. COHON: It will depend very much on what happens in the saturated zone and what assumptions are made about dilution in pumping, as Chairman Jackson was

suggesting.

MS. KNOPMAN: If I can just put my two cents in here. Where the Board has put its effort is in wrestling with the question of technical defensibility, so that when DOE comes forward with an estimate of whether or not it can meet a proposed standard, has it done so with a set of assumptions and data and a scientific community consensus behind it, that it is a credible assessment, even with uncertainties attached, but, nonetheless, credible.

So this is the tough part of figuring out whether these many models that have been developed do have some bearing on reality. Sure, they can show something. It's a question of whether they're showing what we think is actually going to happen there, and that's where the Board wants comfort is in understanding that those modeling representations are a good -- are our best shot at that representation of the system.

CHAIRMAN JACKSON: So perhaps in this context you would replace robustly with credibly.

MS. KNOPMAN: Yes, until we figure out what robust means.

CHAIRMAN JACKSON: Right.

MR. COHON: I'm very glad that Dr. Knopman said what she did. Let me just paraphrase it or expand upon it a little bit. And that is it is not up to the Board to decide

or even comment on what level of uncertainty is acceptable or not, but rather to comment on the methods and the data used to arrive at those estimates of uncertainty.

Thanks for pointing that out.

COMMISSIONER McGAFFIGAN: Let me just ask. Have you all taken a position with regard to what a reasonable standard is?

MR. COHON: No.

COMMISSIONER McGAFFIGAN: You have not.

MR. COHON: No.

CHAIRMAN JACKSON: Commissioner Diaz.

COMMISSIONER DIAZ: Just a quick thing on the same point, I believe. What happens if the uncertainty with any one of the methods is as large as, say, the basic quantity that you're trying to measure, what do you do?

MS. KNOPMAN: That's a social decision.

CHAIRMAN JACKSON: And actually that comes more to the Commission.

MR. COHON: Exactly right.

COMMISSIONER DIAZ: So you are going to be trying to separate this thing so we can actually see what it is. Thank you.

CHAIRMAN JACKSON: Because, in fact, that was what my basic point was going to be, that in the end, the definition of robustly and credibly, et cetera, actually is

a policy, a policy decision, and it's one that's going to end up coming to the Commission.

Well, thank you very much, Dr. Cohon, Dr. Knopman and Dr. Parizek. This was an excellent session and you've raised many of the same issues that the NRC itself has been concerned with, obviously, vis-à-vis the high level radioactive waste program.

If you'd like to make any comment on our own focus on the key technical issues, I'm happy to hear it, but I'm not asking you those questions.

I think hearing from you on a more regular basis as we can move through this pre-licensing phase, particularly with the viability assessment, et cetera, coming through.

Given that, the Commission truly appreciates your taking the time to come and present and talk with us today. There have been a number of key developments in that program that have occurred over the last few years and we look forward to continuing to hear from you.

Unless there are any further comments, we are adjourned.

[Whereupon, at 3:25 p.m., the public meeting was concluded.]

CERTIFICATE

This is to certify that the attached description of a meeting of the U.S. Nuclear Regulatory Commission entitled:

TITLE OF MEETING: BRIEFING BY NUCLEAR WASTE TECHNICAL REVIEW BOARD (NWTRB) PUBLIC MEETING

PLACE OF MEETING: Rockville, Maryland

DATE OF MEETING: Monday, March 30, 1998

was held as herein appears, is a true and accurate record of the meeting, and that this is the original transcript thereof taken stenographically by me, thereafter reduced to typewriting by me or under the direction of the court reporting company

Transcriber: Natalie Penner

Reporter: Mike Paulus

# The Department of Energy's Civilian Radioactive Waste Management Program: An Independent Perspective

**Dr. Jared L. Cohon, Chairman**

**Dr. Debra S. Knopman, Member**

**Dr. Richard R. Parizek, Member**

**U.S. Nuclear Waste Technical Review Board**

**presentation to the**

**U. S. Nuclear Regulatory Commission**

*March 30, 1998*
*Rockville, Maryland*

## Introduction

Chairman Jackson, Commissioners, ladies, and gentlemen, good afternoon. It is a pleasure to be here today. My name is Jared Cohon, and I am Chairman of the U.S. Nuclear Waste Technical Review Board. All Board members serve part-time, and most of us have other full-time jobs. I am president of Carnegie Mellon University and my area of technical expertise is environmental and water resource systems analysis. Accompanying me are two other Board members who will make part of our presentation today. Dr. Debra Knopman is director of the Center for Innovation and the Environment of the Progressive Foundation in Washington, D.C. Her expertise is in hydrology, environmental and natural resources policy, systems analysis, and public administration. Dr. Richard Parizek is a professor of geology and geoenvironmental engineering at The Pennsylvania State University. His expertise is in hydrogeology and environmental geology.

Since we have not met with some of you before, let me begin by briefly summarizing who we are and what we do. The Nuclear Waste Technical Review Board was created by Congress in the 1987 amendments to the Nuclear Waste Policy Act and is charged with evaluating the technical and scientific aspects of the Department of Energy's (DOE's) high-level nuclear waste management program. This includes site-characterization activities at Yucca Mountain and activities relating to the packaging and transport of high-level radioactive waste and spent nuclear fuel. The Board is an independent agency within the federal government, *not* part of the DOE or any other agency. The Board is authorized to have eleven members who are nominated by the National Academy of Sciences and appointed by the President. I have served as a member since 1995 and became the Board's third chairman last year. Drs. Knopman and Parizek were two of eight new members appointed to the Board last year. With this many new members joining the Board at once, we have had a very busy year.

Nuclear Waste Technical Review Board

Created by Congress in 1987 to evaluate the technical and scientific aspects of the DOE's civilian spent fuel and high-level radioactive waste management program including site characterization, waste packaging, and transportation.

Today, in our prepared remarks, we would like to emphasize our views on the key developments of 1997. We will also briefly discuss our views of the upcoming viability assessment, which we expect to be the focus of much of the Board's activities throughout 1998. Our presentation draws heavily on the Board's 1997 Summary Report which we hoped would have been delivered to you before now. Unfortunately, final editing and printing of the report have taken more time than expected, but you should be receiving the report within the next few days. At the conclusion of our presentation, we look forward to a collegial discussion of the type we have greatly enjoyed during the Board's previous presentations to the Commission.

Overview of Presentation

- Progress in the Viability Assessment
- Regulations, Standards, and the EIS
- Transportation
- Technical and Scientific Developments

## Progress in the Viability Assessment

As required by the 1997 Energy and Water Development Appropriations Act, the Secretary of Energy is to provide to the President and Congress a viability assessment (VA) of the Yucca Mountain site no later than September 30, 1998. The VA is to include the following elements:

Components of the Viability Assessment

- Repository and waste package design
- Total system performance assessment
- Licensing plan and cost
- Construction and operating cost estimate

1. The preliminary design concept for the critical elements for the repository and waste package. (The DOE calls this design the "reference design.")
2. A total system performance assessment based on the design concept and the scientific data and analysis available by September 30, 1998. It is to describe the probable behavior of the repository in the Yucca Mountain geological setting in relation to the overall system performance standards. (This component is referred to as the TSPA-VA.)
3. A plan and a cost estimate for the remaining work required to complete a license application.
4. An estimate of the cost of constructing and operating the repository in accordance with the design concept.

The Board intends to conduct a timely review of the parts of the VA that fall within the Board's purview as soon as the VA becomes available. Because the Board is a technical body whose members represent scientific and engineering disciplines, our review will concentrate on technical and scientific aspects of the VA. Essentially, this means that our review will focus primarily on the design and performance assessment components.

Much of the Board's activity during 1997 involved preparation to review the VA. Board meetings during the year focused on performance assessment, hydrology, repository and waste package design, and repository operations. In 1998, we will continue our preparation, and we look forward to reviewing the VA later this year. Now, let me summarize for you the Board's current views on the four components of the VA.

### *Design*

The Board believes that the design area of the Yucca Mountain project had several major accomplishments in 1997. They include refinement of the designs for the repository surface and underground facilities and for the waste package; further integration of spent fuel owned by the U.S. Department of Energy (DOE) into disposal plans; continuing studies of criticality-control issues; and improved integration of engineering and performance assessment. There also were a few shortcomings in the design area in 1997. There are continuing needs to adopt a more robust engineered-barrier system and to thoroughly explore different integrated repository and waste package designs that may offer the promise of better performance, lower cost, reduced uncertainty, or simpler operations.

Design

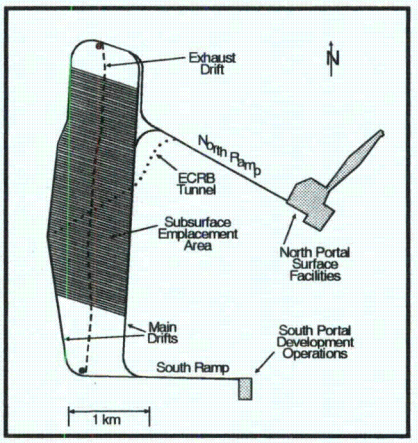
- Several accomplishments in 1997
  - refinements of designs
  - integration of DOE-owned spent fuel
  - studies of criticality-control issues
  - integration of engineering and performance assessment
- Shortcomings
  - need more robust engineered-barrier system
  - need to evaluate alternative designs

*Repository Surface Facilities*

The principal repository surface facilities would be located on an 80-acre site at the repository's north portal and would consist of more than 15 structures and a small railyard. These facilities would receive waste and package it for disposal. Except for the final closure welds and inspections of the waste packages, the Board considers all of the technology of the repository surface facilities to be commercially demonstrated and available. However, the Board does have some remaining concerns about the design basis, including: (1) questions about the assumed peak emplacement rate, which may be unrealistically high; (2) the possibility of transferring some waste packaging operations to nuclear power plant sites, with potential cost savings; and (3) the potential benefits (e.g., safety, standardization) of using multipurpose canisters as part of the overall waste management system. These concerns are discussed in more detail in the Board's 1997 Summary Report.

*Repository Underground Facilities*

This slide shows a plan view of the conceptual repository layout. All underground drifts would have circular cross sections. The diameters of the ramps from the surface to the repository, the main drifts around the periphery of the repository, and the exhaust drift (which would be located approximately 10 m underneath the repository) would be 7.6 m, and the diameters of the emplacement drifts would be 5.5 m. The ramps and most of the east main drift exist now as the recently completed exploratory studies facility (ESF). The balance of the main drifts and the exhaust drift would be constructed next, followed by emplacement drifts, starting from the north.




Waste would be emplaced in the drifts, one at a time, starting with the northernmost emplacement drift, and moving to the next drift south after filling a drift. After an emplacement drift is filled, it would be closed off with doors at each end (i.e., where the drift intersects the main drifts on the east and west sides of the repository), limiting ventilation to insignificant amounts. Human entry into a drift would be prohibited after the first waste package has been emplaced in that drift due to high temperatures and high levels of radiation. Therefore, all operation, maintenance, inspection, testing, etc., in drifts containing waste would be done remotely.

The Board recommends in its 1997 Summary Report that the DOE should develop *alternative repository designs* as well as *enhancements* to the reference design. Although it is neither necessary nor appropriate that the alternatives be developed as fully as the reference design at the time the VA is delivered, we believe that including alternative design concepts in the VA could enhance the VA's value and credibility significantly. Thus, we urge the DOE to consider including alternative design concepts in the VA.

*Engineered Barrier System (Waste Package)*

The reference waste package design is a double-shelled cylinder nearly 2 m in outside diameter by 5 m long with a 2-cm-thick inner shell of corrosion-resistant alloy C-22 and a 10-cm-thick outer shell of carbon steel, a corrosion-allowance material. The waste package will be emplaced on its side on pedestals in the emplacement drift.

Data obtained from the ESF within the last two years clearly show that the repository will be wetter than thought as recently as three years ago. This discovery has triggered examination of enhancements to the existing design. Examples of such enhancements are drip shields and backfill. The Board is particularly interested in seeing studies of additional design options that include: (1) smaller, shielded waste packages, (2) a waste package design using two corrosion-resistant materials (CRM) rather than one CRM and one corrosion-allowance material, and (3) ventilation of the repository tunnels.

The DOE is actively identifying and evaluating enhancements to the reference design. (Enhancements are features that are added to or changed in a design without altering the fundamental nature of the design itself.) We recommend that the descriptions and approximate costs of enhancements be included in the VA and that their effects on long-term repository performance be included in TSPA-VA sensitivity studies.

## *Total System Performance Assessment (TSPA)*

TSPA is the principal method of evaluating the ability of the proposed repository (engineered and natural components acting together) to contain and isolate waste. It is essentially a predictive-computational model of repository performance over time. The DOE is charged with carrying out a performance assessment that emphasizes the *probable behavior* of the proposed repository.

Performance Assessment

- DOE is progressing toward a credible TSPA
- TSPA-VA divided into base case calculation and sensitivity studies
- Workshops increased interactions within the program and brought in outside views

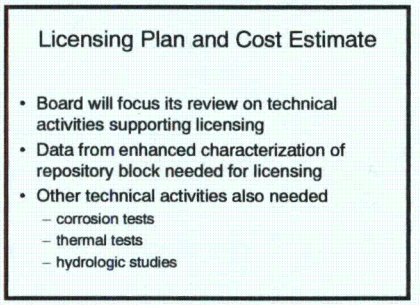
The DOE has devoted significant and laudable effort to achieving the goal of developing a credible TSPA. The emphasis on probable behavior has resulted in a division of the TPSA-VA into a base-case calculation and a series of sensitivity tests. The base case concentrates on probable, or expected, performance, and the sensitivity studies concentrate on "What if?" scenarios for alternative input parameters and design features and disruptive events, such as volcanic activity and earthquakes.

Extensive workshops have increased interaction within the program and have given the DOE substantial expert input from outside the program. The workshops brought together field and laboratory scientists, conceptual modelers, and performance-assessment analysts from within the program on many important topics. Some of the workshops involved eliciting expert judgment, primarily from outside the Yucca Mountain project, to better define the conceptual and parameter uncertainty of the important elements that go into the TSPA. The DOE also formed in 1997 an external TSPA Peer Review Panel to delve into the important concepts and details of the TSPA-VA. The Board is encouraged by the strong

and independent comments being provided by the TSPA peer review panel.

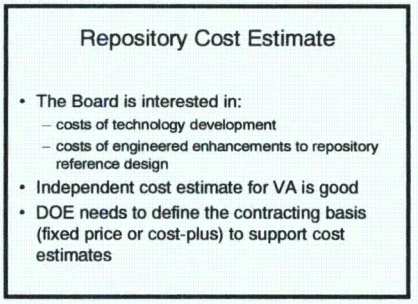
### *Plan and Cost Estimate for License Application*

The plan and cost estimate for a license application is the third element of the VA. The Board will focus its review on the plans for and estimated costs of technical activities supporting a license application. In particular, the Board believes that data from the new enhanced characterization of the repository block (ECRB) program are vital for the Secretary of Energy's decision on the suitability of Yucca Mountain. This decision precedes submittal of a license application to the U.S. Nuclear Regulatory Commission (NRC). Many other ongoing technical activities (e.g., the long-term corrosion test program, the drift-scale thermal tests, and hydrological tests in wells and in the ESF) also must continue to support licensing, and the Board wants to ensure that these activities are included in license application plans and cost estimates.



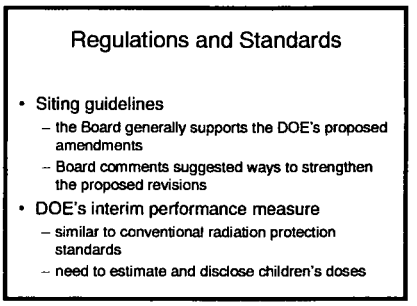

### *Repository Cost Estimate*

This is the fourth (and final) element of the VA. Because the Board's purview is technical, we will confine our review largely to those aspects of the cost estimate that involve technology development. For example, the Board is particularly interested in techniques, allowances, and contingencies used in the cost estimate to reflect the costs of technology development (e.g., manufacture of prototype waste packages, development and testing of robotic or remote handling systems for remote emplacement and monitoring) and to reflect current technical or engineering uncertainties. Another cost issue that the Board will explore is how potential enhancements to the repository design that are not part of the reference design case are handled. The Board was pleased to learn that an independent review of the cost estimate for the mined geologic disposal system will be performed for the VA by a major U.S. engineering-construction firm. It is important that the DOE clearly define for the cost-estimate reviewer the construction process and the contracting basis (e.g., fixed price or cost-plus) that will be used to construct the repository.



## Regulations, Standards, and the EIS

During 1997, the Board reviewed and commented on two aspects of the regulatory requirements for a geologic repository.




### *Siting Guidelines*

On April 15, 1997, the Board submitted comments on the DOE's draft revisions of its repository siting guidelines, 10 CFR 960. In the draft revisions, the determination of whether the Yucca Mountain site is suitable for developing a repository would depend no longer on several individual criteria. Instead, a suitability determination would be based solely on whether the repository system (natural and engineered barriers) can meet a postclosure risk-based standard that will be specified by the Environmental Protection Agency (EPA). In the draft revisions, the DOE proposed using the TSPA methodology to support this determination. In effect, the former, multiple-criteria standard would be integrated and subsumed into a single performance standard.

The Board's April 15, 1997, letter indicated that the proposed revisions represent a step in the right direction. It expressed concern, however, that the revised guidelines might be perceived as "changing the rules in the middle of the game," strengthening the fears of some that performance assessment may be manipulated to support any conclusion desired. The Board offered several suggestions for strengthening the proposed revisions: (1) preserve the principle of defense-in-depth, (2) require that a repository system complies robustly with a standard, (3) specify the level of confidence that must be reached before making a site-suitability determination, (4) make performance assessments transparent, and (5) use a public process to decide whether the Yucca Mountain site is suitable.

### *The DOE's Interim Performance Measure*

In the absence of environmental standards from the EPA, the DOE has developed an interim performance measure. The interim performance measure is for the DOE's own use in guiding its technical program and communicating with others about the potential performance of a repository at Yucca Mountain. The interim performance measure will be discarded if and when the EPA sets standards for a repository at Yucca Mountain. In developing the interim performance measure, the DOE took into account the 1995 report of the National Research Council's Committee on Technical Bases for Yucca Mountain Standards.

The DOE's interim performance measure emphasizes protection of individuals living in the vicinity of a Yucca Mountain repository. Specifically, the annual dose to an average individual in a critical group living 20 kilometers from the repository is not to exceed 25 millirems per year for 10,000 years. Both the form of this performance measure and its level of safety are similar to many existing radiation protection standards. With one exception, this interim performance measure seems appropriate for the DOE's use. The exception is the exclusion of children from the definition of the critical group. The Board recommended that the

DOE should estimate and disclose the likely variation in doses for alternative candidate critical groups characterized by different locations, ages, and lifestyles. In particular, potential doses to children should be compared with doses to adults within each candidate critical group.

### *Environmental Impact Statement*

Assuming that the site is determined to be suitable, the DOE plans for the Secretary of Energy to recommend to the President in 2001 that the President approve Yucca Mountain as a site for a repository. By law, the Secretary's recommendation must be accompanied by an EIS.

Environmental Impact Statement

- Any recommendation to develop a repository at Yucca Mountain must be accompanied by an EIS.
- Reduced funding deferred EIS work in 1996, but work was resumed in 1997.
- NWTRB will begin reviewing EIS-related work in 1998, with particular emphasis on selection and development of alternatives.

Much of the work on the EIS was deferred in 1996 in response to reduced appropriations for fiscal year 1996. In 1997, the DOE resumed work on the EIS in earnest. The DOE's EIS contractor, selected in 1996, mobilized staff, familiarized them with the project as necessary, and began to assemble and analyze data for the EIS. In 1998, the Board will be devoting some of its time to understanding the organization and content of the EIS. In particular, the Board believes that the selection and characterization of the "no action" alternative is critical to the technical success of the EIS process. The Board strongly endorses development of alternative repository and waste package designs and believes that the EIS process is an appropriate venue for exploring these alternatives.

## Transportation

During 1997, the Board reviewed the transportation of spent nuclear fuel within the United States. The Board's review concentrated on federal regulations governing the transportation of spent fuel, analyses of the risks of transportation, and transportation practices and experiences. The Board reached three conclusions.

Transportation

- The risks of transporting spent fuel are low
- Existing capability to transport spent fuel is small and much preparatory work needs to be done to move large quantities.
- Certain measures, such as dedicated trains and full-scale testing of casks, may enhance the perceived level of safety.

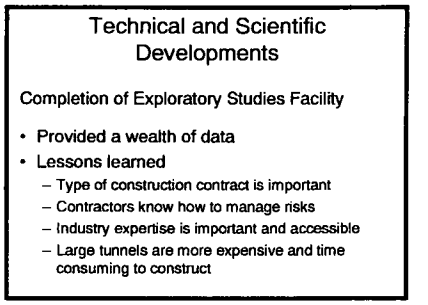
- The Board continues to believe that the risks associated with transporting spent fuel are low. However, if there is a large increase in the scale and operational complexity, as might occur when spent fuel is shipped to a repository or an interim storage facility, a heightened safety program will be needed to maintain a good safety record.

- The existing capability to transport spent fuel in the U.S. is small, and much preparatory work needs to be done before fuel can be transported in large quantities. More transportation casks, with larger capacities, are needed; the transportation infrastructure at some sites needs to be upgraded to allow moving heavy loads; and substantial institutional planning is needed.

- Certain measures, such as use of dedicated trains and full-scale testing of casks, may enhance the perceived level of safety. Because the risks of transporting spent fuel are low, it is unclear whether such measures would be justified solely for risk reduction, but they may increase confidence in the safety performance of the transportation system.

## Technical and Scientific Developments

### *Completion of the Exploratory Studies Facility*




The excavation of the exploratory studies facility (ESF) was officially completed on April 25, 1997, providing a 7,877-m-long (25,800 ft) tunnel at Yucca Mountain. As anticipated by the Board, the excavation of this tunnel provided a wealth of anticipated and unanticipated data on the geologic and hydrogeologic character of Yucca Mountain and was a very valuable learning opportunity for the Yucca Mountain project in performing contractor oversight, managing construction, and understanding the value of seeking independent counsel from construction industry experts. The following are some of the lessons that can be learned from the construction of the ESF.

- The type of construction contract is important. Underground construction worldwide uses competitive processes, normally involving fixed-price contracts. Cost-plus contracts, such as used by the DOE for the ESF, have no known precedent in underground construction and provide little, if any, incentive for efficient, cost-effective construction.

- Contractors know how to manage the risks associated with equipment design and performance. Design, procurement, and disposal of construction equipment, including tunnel-boring machines, normally are left to the construction contractor. Specifications, such as for hydraulic spill mitigation, dust control, and safety requirements, can be defined and enforced without telling the contractor how to perform.

- Industry expertise is important and accessible. In 1995, after experiencing severe difficulties in excavating the ESF, the DOE, in conjunction with its contractor, established a consulting board. This board was very effective in achieving improvements, and the DOE is commended for involving outside expert consultants.

- Large-diameter tunnels are more expensive and time consuming to construct than small-diameter tunnels. The design for a Yucca Mountain repository includes large (7.6-m diameter) tunneling for service tunnels and the exhaust drift. Smaller tunnels would be affected much less by the high fracture density of the rock in the repository horizon and would be much more constructible than the large proposed tunnels.

## *East-West (ECRB) Tunnel*

The Board previously recommended excavation of an east-west exploratory tunnel at the elevation of the repository and parallel to the proposed emplacement drifts. The principal focus of this tunnel would be to obtain data to reduce the uncertainty of the hydrogeologic environment within the repository. The DOE has accepted this recommendation in general, but has expanded the scope to what is known as the "enhanced characterization of the repository block" (ECRB) program, which consists of the tunnel and two boreholes, to be drilled from the surface. All excavation, including three alcoves off of the tunnel, will be completed by January 1, 1999.

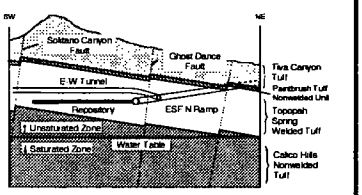
Technical and Scientific Developments (cont'd)

East-West Tunnel

- DOE has accepted the Board's recommendation
- Two boreholes will also be drilled
- Should help reduce uncertainties about hydrologic conditions in the potential repository block

The next slide illustrates conceptually, although not to scale, the location of the ESF, the east-west tunnel, the potential repository, and some of the more prominent geologic features of the site. The Board supports the decision by the DOE to excavate the east-west tunnel expeditiously. Although hydrogeologic testing may not start until 1999, observations, mapping, and limited data on chlorine-36 ($^{36}Cl$), which would indicate possible fast flow paths for water moving through the mountain, may be available before the scheduled delivery date for the VA, thus providing valuable confirmatory data for the VA.

Location of East-West Tunnel, Repository, and Geologic Features




## *Thermal Testing at Yucca Mountain*

One of the primary functions of the ESF is to provide access to the strata in which the repository is to be located to conduct thermal testing, especially the effects of repository heat on movement of water within highly fractured, unsaturated rocks. Data from thermal testing will be useful for validating the various hypotheses and assumptions used in developing performance models and the current repository design. Two tests are being conducted in the ESF, the single-heater test and the drift-scale test.

Technical and Scientific Developments (cont'd)

Thermal Testing

- Single-heater test in cool-down phase
- Drift-scale test started - simulates waste packages in a repository drift
- Large-block test nearing completion

The "single-heater test" has been in its cool-down phase since May 1997, and all testing was to be completed by the end of January 1998. Post-test analyses within this portion of the ESF are planned, and key information should be available for incorporation into the viability assessment.

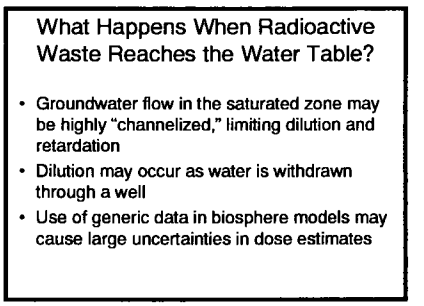
The "drift-scale test" is located in a 47.5-m-long (156 ft) test area equipped with heaters that simulate the thermal conditions of waste packages in a repository. On December 3, 1997, heaters were turned on and data collection was begun from sensors in the surrounding rock mass.

The heating phase is planned to last approximately 4 years, with nominally 4 years for cooling afterward. The DOE is to be commended on implementing this extensive and important thermal test facility.

The "large-block test" is an additional thermal test being conducted on the surface near Yucca Mountain on an excavated outcrop of welded tuff. It was designed to promote formation of reflux (heat-pipe) zones as heat is applied to the bottom of a large block of fractured rock. Water, mobilized as vapor, is expected to be driven out of the pores of the rock and to flow upward where it will condense in cooler regions of the rock. The condensate then will return as reflux to the above-boiling zone. On February 28, 1997, the heaters were turned on, and the test was nearing completion at the end of 1997.

### *What Happens When Radioactive Waste Reaches the Water Table?*

Late in 1997, the Board visited Yucca Mountain and nearby Amargosa Valley for field observations about the flow of groundwater between Yucca Mountain and Amargosa Valley, how groundwater conditions varied in the past as the climate varied, and how any radioactive materials released to the groundwater might, in the future, enter the human biosphere through seeps, springs, or withdrawal through wells.



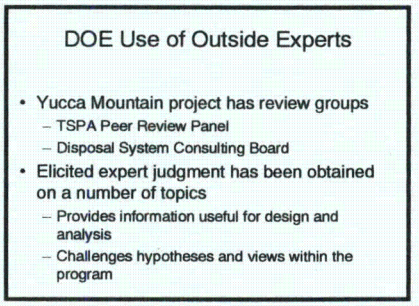

Estimates of the concentrations of radioactive materials entering the environment south of a Yucca Mountain repository will be highly uncertain. The saturated zone is highly fractured and faulted, causing groundwater flow to be "channelized" within the more transmissive zones of fractured rock. Within these zones, groundwater movement will be faster than the average groundwater flow rate through the saturated zone, and retardation of radionuclides may be less than average. Mixing of groundwater containing radionuclides and radionuclide-free groundwater within the saturated zone will dilute radionuclide concentrations, but demonstrating the degree to which mixing would occur in a channelized flow system may prove very difficult.

An important, and perhaps greater, source of dilution may be mixing at a wellhead (or a spring) when groundwater leaves an aquifer and enters the biosphere. This depends on the specifics of the well withdrawal. Dilution by flow and transport in the saturated zone is difficult to quantify. Because of its significance in determining the relative importance of the different factors affecting dilution, an early definition of the well-withdrawal scenario could provide an important focus for studies at Yucca Mountain.

The fate of radionuclides after they enter the biosphere and as they enter food chains and potentially cause radiation doses to humans must be projected. The use of generic data in models of the transfer of radionuclides through food chains may cause large uncertainties in estimated radiation doses, perhaps as much as three or four orders of magnitude.

## *DOE Use of Outside Experts*

The Yucca Mountain project is receiving valuable advice from two DOE-funded external review groups: the TSPA Peer Review Panel and the Yucca Mountain Site Characterization Project Mined Geologic Disposal System Consulting Board. In the past, the Board has urged the DOE to make greater use of expertise outside of that already found within the Yucca Mountain program, and the Board is pleased that the DOE is doing so.




The Board's 1997 Summary Report discusses another type of external input: recent, specially elicited expert judgment. Expert judgment is required when dealing with an inherent uncertainty in scientific understanding or when there is a need to make an assessment before all relevant data can be collected. An example of the latter is the TSPA for the VA. Although informal implicit or explicit expert judgment from one or more Yucca Mountain scientists has always been used in performance assessment, the recent elicitations are formally structured studies that involve multiple experts, most of whom are from outside the Yucca Mountain program. The topics covered by the expert studies (some of which are not yet complete) include seismic and volcanic hazards, unsaturated-zone flow, waste package degradation, saturated-zone flow and transport, near-field/altered-zone coupled effects, and waste form degradation and radionuclide mobilization. A primary purpose has been to describe the uncertainties associated with particular models and data.

Overall, the elicitations have proven very successful. The DOE is commended for carrying out these studies and, in particular, for including a substantial number of outside scientists and engineers on the expert panels. Aside from supplying information that can be used directly for performance assessment and design, the elicitations have provided important insights into the program. They include the endorsement or rejection of previously accepted scientific models and design assumptions; the importance, or lack thereof, of different hypotheses; and the need to acquire selected additional data. The challenge to the DOE is to make full and effective use of the experts' input.

In making full and effective use of the expert elicitations, the DOE needs to articulate how it intends to aggregate the views of multiple experts and address the potential problems posed by receiving input on some issues from only a small number of the experts who were asked. This is especially important when there are relatively few experts and they differ sharply on meaningful issues. Sufficient information must be presented to trace the effect of an individual expert's judgment on overall conclusions. The DOE needs to explain whether and how the views of individual experts will be treated in sensitivity studies for the TSPA-VA, and it also should consider developing guidelines on how it will treat the results of an expert elicitation in the light of new data and analyses.

This concludes our prepared presentation. We will be happy to answer any questions you may have.