UNITED STATES

NUCLEAR WASTE TECHNICAL REVIEW BOARD

FALL MEETING

September 20, 2004

Atrium Suites Hotel
4255 South Paradise
Las Vegas, Nevada 89109

NWTRB BOARD MEMBERS PRESENT

Dr. Mark Abkowitz, Chair, Afternoon Session
Dr. William Howard Arnold
Dr. Daryle H. Busch
Dr. Thure Cerling
Dr. David Duquette, Chair, Executive Committee
Dr. B. John Garrick, Chair, NWTRB
Dr. George M. Hornberger
Dr. Ronald Latanision
Dr. Ali Mosleh
Dr. Henry Petrosky

OUTGOING BOARD MEMBERS

Dr. Norman Christensen
Dr. Priscilla Nelson
Dr. Richard R. Parizek

SENIOR PROFESSIONAL STAFF

Dr. Carl Di Bella
Dr. Daniel Fehringer
Dr. Daniel Metlay
Dr. Leon Reiter
Dr. David Diodato
Dr. John Pye

NWTRB STAFF

Dr. William D. Barnard, Executive Director
Joyce Dory, Director of Administration
Karyn Severson, Director, External Affairs
Linda Coultry, Management Assistant
Alvina Hayes, Office Assistant

I N D E X

PAGE NO.

I N D E X
(Cont.)

P R O C E E D I N G S

8:00 a.m.

DUQUETTE: Good morning, and welcome to the fall meeting of the U.S. Nuclear Waste Technical Review Board. My name is David Duquette. I'm chairman of the Executive Committee of the Board, and I've had the honor and privilege for the last nine months, or so, of being Acting Chair of the Board.

I do have one administrative announcement that I'd like to say before anything else, and that is if you have cell phones, please turn them off now so that we don't have any interruptions during the meeting.

We have some changes on the Board this morning, and it's a great pleasure to introduce, and I will introduce our new Chairman, Dr. John Garrick. As many of you may know, the President signed the appointments for Dr. Garrick and six other new members, who you'll be introduced to shortly on September 10, 2004.

Let me say a few things about Dr. Garrick. He received his doctorate in engineering and applied science from the University of California in Los Angeles. His fields of study include neutron transport, applied mathematics, and applied physics. John was the founder and executive officer of PLG, Incorporated, an international engineering, applied science, and management consulting firm specializing in the application of risk science to technology-based industries. He retired from PLG in 1997, after 22 years of service, and I can promise you that wasn't a real retirement. It was only a phoney retirement, because he's been extremely active since then.

Throughout his career, John has contributed significantly to the development and application of the risk sciences to many technology-based industries. His work in analytical methods and probabilistic risk analysis is widely known and highly regarded. He has been a driving force in evaluating risk assessment to a scientific and engineering discipline.

For the last ten years, John has been a member of the U.S. Nuclear Regulatory Commission's Advisory Committee on Nuclear Waste. He chaired that committee for four of those years. He was President of the Society of Risk Analysis from '89 to '90. He has been a member and chair of several National Research Council committees; served as a vice chair of the National Academy of Sciences Board on Radioactive Waste Management; was a member of the National Research Council Commission on Geoscience, Engineering and Resources; and is a member of the first class of lifetime national associates of the National Academies. John is a registered professional engineer in the State of California, obviously an impressive set of credentials, and John will be of tremendous benefit to the Board with his knowledge and his background, and will provide us the leadership that the Board looks for in all of its members. We look forward to working with you, John.

I want to take this opportunity to extend our thanks and appreciation to some outgoing Board members. There are several who are here today, and I'd like, if they would, to make a couple of comments, brief, as Board members are always brief in their comments on the Board.

Norm Christensen was supposed to be here. He had a personal situation arise, so will not be here this morning. Norm was a tremendous asset to the Board, and will be tremendously missed. He is a Professor of Ecology and the former Dean of the Nicholas School of Environment at Duke University. He was appointed to the Board by President Clinton in 1997. He served on most of the Board Panels, and has been extremely active in the Waste Management Panel. He provided leadership in the Board's review of the DOE's Yucca Mountain EIS, in communicating the Board's evaluation of DOE's work related to the site recommendation, and in formulating many Board technical findings and recommendations. I can promise you that as a Board member, Norm will be sorely missed.

Priscilla Nelson is senior advisor to the Directorate of Engineering at the National Science Foundation in Washington. She was also appointed to the Board by President Clinton in January of 1997. She is a member of several Board Panels, including the Repository System and Performance Integration Panel, the Natural System Panel, and the Engineered System Panel. She's made a major contribution in helping establish the need for an exploratory cross drift, the Board's drift, if you will, the Board's tunnel, through the proposed repository waste emplacement area. She participated in the Board's ongoing review of the repository subsurface design while maintaining a keen interest in natural systems.

Priscilla, a word or two from you.

NELSON: Nelson, Board.

My comments are very brief. The times that I was a Board members were interesting times, and the future will be interesting as well, and constantly changing. It's been a pleasure to serve on the Board, with colleagues on the Board and with colleagues not on the Board. The interactions have been wonderful, constantly growing.

My focus has always been on the mountain, on the science, on the rock, and on the water, and I think appropriate ------ to be there still. So, I encourage that kind of focus.

Thank you.

DUQUETTE: Thank you very much, Priscilla.

Richard Parizek, Professor of Geology and Geoenvironmental Engineering at Penn State and President of Richard Parizek Associates. He was appointed to the Board by President Clinton in February of 1997. He served on the Repository System Performance Integration Panel, and was Chair of the Natural Systems Panel. It was in this capacity that he made his most recent contribution, the preparation of the Board's May 2004 letter on the Natural System. Richard will be remembered for the enthusiasm with which he approached his participation on the Board--that's somebody else's language, not mine. Richard has been a really esteemed colleague. It's been a great pleasure working with him, and those are my words, and, Richard, would you say a word or two before leaving?

PARIZEK: It's been an honor and a privilege and a real responsibility to serve on the Board, for eight and a half years, and then about a year and a half as a consultant in transition getting out of the Board. And, during that time period, we've worked with some incredible staff, technical staff and support staff from the Board. These are dedicated public servants, unlike what you would typically hear when people talk about what's going on in Washington. It's also true of the DOE staff, the technical people, and the leadership of it through Margaret Chu, and previously, Lake Barrett. These are people who also have been dedicated, receiving often external criticisms, and they're not justified in terms of the responsibilities they've had, and the way they've tried to carry that out. So, it's really been really a privilege to see this process through this time period.

I started when the TRB boring machine was just getting underway, so you can kind of realize where I come from in terms of my observations. Through that time period, I'd say rocks matter, and I've always tried to say rocks matter. And, in the time now when we may not have a 10,000 year standard, we may have, who knows what time period, rocks will still matter. And, some people won't say--well, they won't give us that much credit, therefore, we won't spend much more time on rocks. The point is, they create the environment, the repository environment, if you don't even care about their flow and transport role.

So, I think of the Teton Dam example, a good design for the dam elements, rocks that did their thing. When you put the two together, there was a massive failure. And, this linkage between the rocks and the natural environment that they pose, and the geochemical environment they pose, is critical to this whole process.

I would hope that the science and technology program and others in this DOE effort will pursue some of the points which the Natural Systems Panel people talked about through this time period. One, we had a design to reduce uncertainty in terms of the performance assessment related to flow and transport, both on the unsaturated zone and saturated zone, and if the time period is 100,000 years, a million years, surely geological input to this thing has to be perhaps strengthened in many ways. This is large scale geological testing of faults, which we talked about, to make sure you really don't have a conceptually flawed model for Yucca Mountain. Everybody's flow heads southeast in the alluvium and then south, but it could be conditions under which it actually stays in the bedrock, in which case that would be troublesome.

On the other hand, the alluvium itself, based on drill holes that we've recently seen from Nye County, have matrix properties which would slow--transport through the matrix interaction, not only of the volcanic tufts, but also the alluvial materials. And, so, characterizing that, getting credit for it, through all the tests, the C-well testing and the reinjection of fluids, for instance, with microspheres, that idea apparently is generating interest, and on and on, there's a whole series of points we've tried to raise to add credibility to the standing of this process.

And, having put this much energy into this process, I will not let it go. I will support that, but I'll be citizen Parizek, I guess I already am now, but I will follow the progress of the group, and wish everyone well in the months and years ahead.

I have two fortune cookies. One is perhaps a 10,000 year one. The other one is an uncertain one. I didn't open either, because I'm not sure what the message might be. But, I wish you all God speed and good luck for the benefit of the nation and the people concerned with this critical issue.

DUQUETTE: Those of us who are still serving on the Board, and those new Board members, really appreciate your service. I'm not sure that all of the public realize how much time and effort is put into this. Virtually every member of the Board has a day job, and whatever happens here, is done in addition to what they do otherwise.

Having served with the two individuals who are here, and with Norm, who is not here, has been a great privilege, and I can tell you how much extra work they've put into it. It's been an honor, a real honor to serve with them. They're dedicated people, and extremely intelligent people, and it's been my great privilege to have served with them.

And, with that, I want to turn the Chair over to John Garrick.

GARRICK: Good morning. Thanks, David, for your introduction and very, very generous and kind remarks.

I also want to take this time to recognize the important leadership you have provided for the last ten months or so, and how much that is appreciated by the Board, the staff, and I'm sure everybody that's involved with the project.

As I take on this daunting task of Chairing the distinguished group and become engaged with my colleagues on the technical and scientific evaluation of activities related to nuclear waste disposal, I can't help but reflect on how different this Nevada experience is from another time when I was closely connected to the State.

It may come as a surprise to many of you, but I spent a considerable amount of my growing up time connected with Nevada. A substantial fraction of my primary education was in, of all places, Lincoln County in two communities by rather novel names, Panace and Pioche. I still see bumper stickers from time to time that indicate "Where the hell is Pioche?" and it's for a reason. My late brother went to all four years of high school at Lincoln County High School, where is starred as a basketball player, a football player, and was a student body officer.

The first motion picture I ever attended was in a household name, a town of a household name to all of us now, Caliente. It was family night, all six of our family was able to go to the movie for 50 cents. That's not individually, that's for the whole family.

There were many other firsts for me connected with the State as well. My first encounter with a rattlesnake was as a toddler in the back yard of a Union Pacific house on the mainline of the Union Pacific that's in a town that's not even on the map anymore, at least the last map I looked for it, by the name of Rox. That's spelled R-o-x. It could have just as well been spelled R-o-c-k-s. At the time, the town's only purpose was a pumping station, and to provide water for the steam locomotives of the Union Pacific Railroad. My father happened to work in the pump house.

I first learned to play a musical instrument in this State. I first had my experience with organized sports in Nevada. And, I had my first encounter with being thrown off a horse here as well. I will never forget that. There are many other things that I could tell you about, but I won't bore you anymore with my life in Nevada, because I want to get on and add to Dave Duquette's welcome to you all, and spend some time talking about the Nuclear Waste Technical Review Board, and especially the new members.

As many of you are aware, the Board meets three to four times a year. Many of its meetings are held in Nevada to provide the citizens with an opportunity to observe the presentations and comment on the material that is presented.

The Board was created in 1987, in accordance with the 1987 amendments of the Nuclear Waste Policy Act. Congress established the Board as an independent federal agency to evaluate the technical and scientific validity of activities of the Secretary of Energy relating to the disposal of commercial spent nuclear fuel and defense high-level waste. The Board also evaluates DOE activities related to packaging and transportation of the waste, and the Board is required to report its findings and recommendations at least twice a year to Congress and the Secretary of Energy.

The President appoints Board members from a list of nominees submitted by the National Academies. The Board is, by law and design, composed of a multi-disciplinary group of experts with a wide range of experience. A full Board consists of eleven members. As David told you, the President signed the appointments of seven new Board members. That was done on September 10th. And, with the exception of Andrew Kadak, we are all here today.

Let me remind you that the Board members serve in a part-time capacity, as indicated by David. We all have other jobs. As you've already heard, my background is physics and engineering, with over 40 years experience in the development and application of the risk sciences.

Let me now introduce the other Board members. I would ask that they raise their hands as their names are called, and I'll begin with the continuing members.

Mark Abkowitz. Mark is Professor of Civil Engineering and Management Technology at Vanderbilt University in Nashville, Tennessee, and is Director of the Vanderbilt Center for Environmental Management Studies. His areas of expertise include transportation, risk management, and risk assessment.

Thure Cerling. Now, Thure is arriving late today. He'll be here before noon. Thure is a Distinguished Professor of Geology and Geophysics and a Distinguished Professor of Biology at the University of Utah, Salt Lake City. He is a geochemist, with particular expertise in applying geochemistry to a wide range of geological, climatological, and anthropological studies.

David Duquette, whom you've already met. David is Department Head and Professor of Materials Engineering at Rensselaer Polytechnic Institute in Troy, New York. His areas of expertise include physical, chemical, and mechanical properties of metals and alloys, with special emphasis on environmental interactions.

Ron Latanision. Ron is Emeritus Professor of Materials Science, Professor of Nuclear Engineering, and former director of the H.H. Ulig Corrosion Laboratory at MIT. Ron is Principal Engineer and the Mechanics and Materials

Practice Director for the consulting firm of Exponent in Boston, Massachusetts. His areas of expertise include materials processing and corrosion of metals, and other materials in different aqueous environments.

Let me now introduce the new members.

Howard Arnold. Howard is a consultant with 40 years experience in the nuclear industry. During that period, he served in senior management positions, including vice-president of Westinghouse Hanford Company, where he was responsible for engineering, development, and project management. Before his retirement in 1996, he was president of Louisiana Energy Services, an industrial partnership formed to build the first privately owned uranium enrichment facility in the United States. From 2001 to 2002, he served as Chair of a National Academies Committee that assessed the scientific basis for disposal of special nuclear materials.

Daryle Busch. Daryle is the Roy A. Roberts Distinguished Professor of Chemistry at the University of Kansas in Lawrence. He also is deputy director of the National Science Foundation Engineering and Research Center at the University of Kansas, having the title of, "Center for Environmentally Beneficial Catalysts." His research is presently focused on homogeneous catalysis, bioinorganic chemistry, and orderly molecular entanglements. That sounds pretty interesting, orderly entanglements. Daryle is a recent Chair of the Chemistry Section of the American Association for the Advancement of Science.

George Hornberger. George is the Ernest H. Ern Professor of Environmental Sciences and Associate Dean for Sciences at the University of Virginia. His research interests include catchment hydrology, hydrochemistry, and the transportation of colloids in geological media. He has served as Chair of a number of committees, including the National Research Council's Board on Earth Sciences and Technology, the Commission on Geosciences, Environment and Resources, and, as you heard earlier, the NRC's Advisory Committee on Nuclear Waste.

As I mentioned earlier, Andrew Kadak is unfortunately unable to be with us today. Andy is Professor of the Practice in the Nuclear Engineering Department of MIT. His research interests include the development of advanced reactors, space nuclear power systems, improved technology-neutral licensing standards for advanced reactors, and operations and management issues of existing nuclear power plants. Andy was President of the American Nuclear Society for the year 1999-2000.

Ali Mosleh. Ali is Professor and Director of the Reliability Engineering Program in the Mechanical Engineering Department at the University of Maryland. He has performed risk and safety assessments, reliability analyses, and decision analyses for the nuclear, chemical and aerospace industries. He serves as Chairman of the Engineering Division of the International Society for Risk Assessment and Management, and is Director of the X-Ware Systems Reliability Laboratory, focusing on the reliability of integrated hardware-software-human systems.

Henry Petrosky. Henry is the Alexander S. Vesic Professor of Civil Engineering and Professor of History at Duke University. His current research interests are in the areas of failure analysis and design theory. Ongoing projects include the use of case histories to understand the role of human error and failure in engineering design, as well as models for inventions and evolution in engineering design. Professor Petrosky is the author of several books. My favorite is "To Engineer is Human: The Role of Failure in Successful Design."

We are pleased that the two of three departing Board members, Priscilla Nelson and Richard Parizek, will participate in the meeting as Board consultants. We are glad to have you here.

The Board is fortunate to have an outstanding staff to support its activities. The staff is led by its capable Executive Director Bill Barnard. Raise your hand, Bill. The staff is seated along the wall to my left.

Let me now turn to the agenda. First, this morning, we're going to hear from Dr. Margaret Chu, Director of the DOE's Office of Civilian Radioactive Waste Management. Dr. Chu will update us on the status of the Yucca Mountain Program.

Following Dr. Chu's presentation, John Arthur, Director of the Office of Repository Development for the project, will present an overview of project activities and project plans for fiscal year 2005. With less than three months to go before the DOE's planned submittal of a License Application, the Board is particularly interested in John's presentation.

After the morning break, Rick Craun, Acting Director of the Office of Management and Engineering, will discuss the repository design that will be included in the DOE's License Application. For many of the new Board members, this presentation will be an introduction to the DOE's repository-design and repository-operations concept.

John Ake, Geophysicist with the Bureau of Reclamation and DOE, will then provide an update on seismic issues. Many of you will remember that at the Board's meeting in May, John updated the Board on DOE activities in the seismic area, specifically the project's approach, its methodology, and plans to limit ground motions. This morning, John will present the project's results and explain how ground-motion criteria have been incorporated into the repository design for License Application.

Following the lunch break, Mark Abkowitz will Chair the afternoon session, which is entirely devoted to issues related to Total System Performance Assessment. Bob Andrews, Manager of Postclosure Safety for Bechtel SAIC, will make three presentations for the DOE, beginning with the regulatory requirements and scope of the DOE's Performance Assessment for License Application. Bob's second presentation will be on the DOE's approach and methodology for the Performance Assessment to be the basis for the License Application. This will include features, events, and processes known as FEPs. Bob's third and final presentation will focus on DOE's Performance Assessment models, and the use of scenario classes, input parameters, and logic diagrams. He also will point out changes to the current Performance Assessment and describe how Performance Assessment will be documented. At the end of these presentations, we will take a short break.

Following the break, Tim McCartin, Senior Advisor for Performance Assessment at the Nuclear Regulatory Commission, will talk about risk insights and the criteria for NRC review of Performance Assessment.

The final presentation on Total System Performance Assessment will be made by Mick Apted, Executive Consultant for Monitor Science, who will present and discuss the

Electric Power Research Institute's approach to Performance Assessment, including their latest results.

At the end of each presentation, there will be allowed time for questions and discussion, that is, if I don't take up all the time with this introduction.

A public comment session has been scheduled after the conclusion of the afternoon presentations at 5:30 p.m.

Before we get started, we need to take care of some business items. First, the Board values public participation. And, so, as I just mentioned, we have set aside time this afternoon for this important activity. If you would like to speak during the public comment session, please add your name to the sign-up sheets at the registration table at the back of the room, where Linda Coultry and Alvina Hayes are seated. Linda and Alvina, please raise your hands, so people can see where you are. Thank you.

Most of you have attended Board meetings know that an effort is made to accommodate everyone during the public comment period. But, as you can see, we do have a very full agenda. So, depending on the number of people who want to speak, we may have to set a limit on the time allowed for individual comments. As always, you are welcome to submit comments in writing. If you have questions that you'd like to have the Board ask, related to topics being discussed, please give them to Linda or Alvina. If time permits, session chairs may raise the submitted questions.

I must offer the usual Board disclaimer for the record, so that everybody is clear about the conduct of our meeting, what you're hearing, and the significance of what you're hearing.

Board meetings are spontaneous by design. Those of you who have attended Board meetings before know that the Board members speak frankly, and openly voice their personal opinions. But, I want to stress that when the Board members speak extemporaneously, they are speaking on their own behalf, not on behalf of the Board. When a Board position is articulated, we'll be sure to let you know. Board positions are stated in Board letters and reports and can be accessed from the Board's website at www.nwtrb.gov.

Finally, I'll ask, as Dave Duquette did, all of you to please take a few seconds to confirm that your cell phones and pagers are switched to the silent mode.

(Pause.)

I'll now begin the meeting by introducing Dr. Margaret Chu, Director of the Office of Civilian Radioactive Waste Management, who will update us on the status of the project. Margaret?

CHU: Good morning. The first thing I'd like to do this morning is to express my appreciation to the departing members of the Board, Dr. Nelson, Dr. Parizek, and Dr. Christensen, even though he's not here. You have participated as Board members since 1997, and have fully served the terms to which you were appointed to. You have reviewed our activities and provided important insights over a critical period in the program's history.

As the Department of Energy developed, the viability assessment, completed the site characterization, prepared the documentation to support the site recommendation, and transitioned to the licensed phase of the program. And, that I thank you, and I wish each of you the best of your ongoing careers and future endeavors. I also would like to thank Dr. David Duquette for serving as Acting Chair since last January. Thank you.

I'm very pleased to meet the new members of the Board, and to welcome the new Chairman. Your extensive scientific, technical, and engineering expertise and disciplines are central to the repository development. It will be very beneficial to the Nuclear Waste Management Program. I'm looking forward to your participation for many years to come.

Our office, the Office of Civilian Radioactive Waste Management, within DOE, and the Nuclear Waste Technical Review Board, were both created by the Nuclear Waste Policy Act. We, OCRWM, in 1982 entered the Board by the '87

Amendments Act, and our two organizations also shared the same basic goals, to follow the law, to establish a sound scientific basis for repository development, and by doing so, ultimately, to protect the public.

Under the current law, a repository at Yucca Mountain will secure 70,000 metric tons of spent nuclear fuel and high-level waste at a highly protected underground location far from population centers. Without a repository, this material will remain scattered at 125 sites around the country, many near major cities. I would like to remind myself and everyone else that that's what we are all about.

OCRWM's responsibility for implementing the law is actually rather straightforward. We follow the Nuclear Waste Policy Act, which laid out the step by step process for the entire life cycle of the repository development. It defines steps for the site investigation, site recommendation, and an approval of a repository site for a rigorous licensing process, for planning and coordinating transportation, and for eventual closure of the repository. This step by step process provides appropriate points for the review of findings in the reaffirmation of policy direction at the national level, while enabling the implementing agencies to focus on their respective responsibilities.

One of the most important effects of the '87 Amendments was the creation of the Nuclear Waste Technical

Review Board to evaluate the technical and scientific validity of the activities leading toward repository development. The level of expertise that Board members bring to bear, the range of disciplines, and the independence of the Board enhances its value, both to the program and to the nation.

When I came on board as Director of OCRWM in 2002, one of my objectives was to get the full benefit of the Board's expertise and their ability to focus on critical issues. We are committed to sound science as the foundation of the Nuclear Waste Management Program, and will protect the citizens of the State of Nevada and the nation. I am personally committed to ensuring that we do our scientific and technical work correctly and completely, so that we present a sound scientific basis for repository licensing, and, then, I look to the Nuclear Waste Technical Review Board to continue to assist us with evaluating, challenging, and improving that scientific basis.

Over the years, the Board has challenged us to examine scientific concerns raised by others, and to clarify and communicate our own positions effectively. The Board has looked at site characterization, tunnel boring techniques, repository designs, waste package corrosion, seismicity, and many other issues. We have taken your critique very seriously and investigated the questions you have raised.

The Board has been instrumental in increasing confidence in the Nuclear Waste Management Program, and have helped us produce stronger technical products.

One of the reasons why an independent Board is so important is its ability to focus closely on scientific and technical topics. By contrast, we senior managers at DOE are not only managing our ongoing technical work, but also dealing with several legal and regulatory issues, as well as funding uncertainties. But, today, let me state that our goal of accepting waste at a facility licensed by NRC is important to the nation, and we will continue to work toward that goal. Many activities will have to be completed for this goal to be achievable, and sufficient funding will have to be provided and sustained to support licensing and construction and transportation system development. We're working very hard to complete our license application for acceptance by the Nuclear Regulatory Commission.

As you can imagine, it is a formidable challenge to present the results of over two decades of technical work in a document of this type. I assure you that we're working toward the highest quality application possible, one that will comply with all the applicable laws and regulations, and meet standards to ensure the public health and safety.

Once a license application is received, the Nuclear Regulatory Commission will determine when and how to proceed with our license application. Ultimately, NRC will decide whether or not Yucca Mountain will move forward. No waste will be emplaced until NRC determines that it's safe for DOE to proceed.

Before I turn to today's agenda, I would like to spend a couple minutes to quickly describe the OCRWM organization for those new Board members who may not be familiar with it.

My office consists of a two-armed structure. I have two deputies, one in D.C. headquarters, Ted Garrish, he's in charge of strategy and program development, and then another deputy out West in Las Vegas, John Arthur, who's in charge of repository development, including license application. John Arthur later on will tell you a little bit about the structure under the Repository Development, so I won't repeat that. But, at headquarters, basically we have four offices in D.C. One is the usual, the most important is the business function, budget, human resource, IT, and all these things. The second office is what we call systems analysis and integration, whose function is to optimize and integrate everything in the program, that includes the repository, waste acceptance, and transportation. And, then, the third office is the National Transportation Program, which is in charge of development of the transportation system for this program, both at the national level, and in

Nevada. And, the fourth office was actually created rather recently, about two years ago, is a Science and Technology International Program, whose function is to continue long-term science and technology work, and to leverage new information and new technology evolving down the road, so we can enhance our repository system, and continue to increase confidence and reduce uncertainty.

This morning, John Arthur will update you on our recent accomplishments and the work remaining to be done for the license application. Rick Craun works for John Arthur, will focus on one aspect of this work, which is the repository design for the license application. You will also hear the update on the status of the work on seismic issues by John Ake from the U.S. Bureau of Reclamation.

During the afternoon session on Total System Performance Assessment, Bob Andrews will provide an overview of the Yucca Mountain TSPA, the regulatory background, and an approach to demonstrate repository safety.

TSPA is the tool and methodology used to assemble 20 years of scientific work in a risk-based approach to demonstrate post-closure long-term safety of the repository. So, I think it is a very appropriate topic for DOE to present to you today, especially to the new Board members. So, you will hear from scenario formulation to model development, all the way to compliance calculation, and you will hear a good overview of the post-closure analysis. In addition to the DOE presentations, I really look forward to NRC and EPRI's presentation on TSPA, as well as the views of the Board.

While most of the Board's attention lately has centered on scientific matters related to licensing, there are, as you are aware, two other areas of work that must be accomplished in order to have an operating repository. We look forward to participating in the upcoming meeting of the Board's Panel on the Waste Management System, focusing on transportation in mid-October.

In closing, on behalf of the Department, I want to again thank the outgoing members of the Board for their service, and then I'm pleased to welcome Dr. Garrick, the incoming Chairman, and Dr. Arnold, Dr. Busch, Dr. Hornberger, Dr. Mosleh, and Dr. Petrosky, as well as Dr. Kadak, even though he's not here today.

The Nuclear Waste Technical Review Board again, at it's full eleven member strength, it hasn't been this way for a while, has a critical oversight road in the nation's Nuclear Waste Management Program. I look forward to an open and productive technical interchange with you.

Thank you. I'd be happy to answer questions, as long as they're not hard questions.

GARRICK: Any questions from the Board? Yes?

HORNBERGER: Margaret, I notice you didn't say anything about some recent developments, such as the court's decision. Could you comment on how that might influence your program schedule?

CHU: I'm sure you're aware that, you know, EPA recently announced that they're not going to appeal to the 10,000 year ruling, and they are developing regulatory approach to address that ruling. And, then, our role here, you know, we're here to follow, our job is to follow the applicable laws and regulations. And, so, we have to wait and see what's coming down.

GARRICK: Mark?

ABKOWITZ: I'm Abkowitz, Board. If I could follow up, Margaret, on George's question and your answer? Is it still your intention, DOE's intention, to submit the license application in December? And, if so, what target are you shooting your Performance Assessment around, since we don't know what the target is at this point in time?

CHU: Yes, we continue to prepare our license application at full speed, you can hear from John Arthur later on, according to our current schedule. This is what we're doing right now, and we believe this will provide the public information, address questions on the safety of the repository. And, of course, our job is to follow the applicable laws and regulations.

So, while we're doing that, and I believe it's best for us to put everything down, you know, because there's 20 years of scientific work, that's what we're doing, and preparing a high quality license application according to what we have right now. And, we will submit when it's time to submit, let me put it this way. But, the schedule is still on.

GARRICK: Richard?

PARIZEK: Parizek, Board, Margaret. Let me ask with regard to the long-term option that maybe the 10,000 year standard wouldn't apply, and then, of course, you don't know what the outcome of this will be. But, meantime, to sort of prepare for the alternatives, obviously, water is a key to this whole performance question, and I'm not sure where DOE stands now with regard to ventilation, that is, the passive post-closure ventilation, whether to enhance it or to engineer it in such a way that you have a passive ventilation as a way to control moisture. And, as a citizen/consultant, I would say that the long-term future, if the mountain is dry, then all of the analog examples that the U.S. Geological Survey and others have shown over the years of the stability, long-term survivability of artifacts that are delicate by comparison to waste packages, would apply. So, it seems to me that the passive ventilation upgrade is something that could appear in the science technology area, if it isn't in there now, or could you comment and tell me what your thoughts on this are? I say keep it dry, enhance the keeping of it dry, and in which case, then this 100,000 year, 500,000 year possibility seems more credible because of this whole question of the metal stability and the long-term ability to predict--

CHU: This is a very good point, yes. I'll tell you what we're doing. We're looking at the whole spectrum of things, from scientifically, and we're looking at that type of things, plus add other information. And, we believe the mountain is a very good site, and we're trying to look into all these scientific areas that, you know, for 10,000 years may not seem that important or relevant, because, you know, the regulation, but I think we have a whole spectrum of information related to this whole thing, and we are looking at all of that.

PARIZEK: Parizek, citizen/consultant. One more point. It is the whole idea of the moisture redistribution at the time the repository cools down, sort of looks like the cross drift, with humidity, condensation, dripping on the floor, the whole question of puddling of water, and the whole idea that maybe the drift shadow disappears because of the redistribution of moisture, all of these are the kinds of things that occur to me that this passive ventilation enhancement concept tends to remove from this list of threats to repository performance.

CHU: I agree. Actually, our science and technology program is looking at starting to look at some of those concepts, yes.

GARRICK: Other questions? Any questions from the staff?

(No response.)

GARRICK: All right. Well, thank you very much.

CHU: Thank you.

GARRICK: John? I might indicate to the new Board members when you have a question, indicate your name and that you're a member of the Board, and they do this very succinctly by just giving their last name, and then follow that by Board, for the recorder.

ARTHUR: Okay, good morning. And, I want to welcome everyone to Las Vegas for this NWTRB meeting. For the new members that haven't had a chance to meet yet, I'm John Arthur. Margaret mentioned, I'm one of the two Deputy Directors. I'm responsible for Office of Repository Development, which is the license, test program, engineering, design and repository planning.

Just as far as additional background, I've been in now the Department of Energy for about 25 years, also in private sector for about three years, and I've worked around the system in environmental management, national security, the nuclear weapons complex, and then previously in the Waste Isolation Pilot Plant. So, I want to add onto Margaret's comments, I do look forward to working with the new Board members, under Dr. Garrick's leadership, and also I really appreciate relationships and discussions we've had, Richard and Priscilla and also Norm. So, I wish you all the best in future endeavors, and you'll have my commitment of open exchange of information, frank responses to the comments, and continuing dialogue in the future.

Before I start, I wanted to just, before I get into some of the specific areas, the purpose is really to describe what's really happened since the last meeting, which was May 18th and 19th, the full Board meeting, talked a little bit about issues, accomplishments we've had, and then also talked specifics on the license application, design, and also an area that's of equal importance is the management quality assurance, and other key areas of our program.

One area I want to mention, I think you're all taking a tour out to the site on Wednesday, and I do apologize that you can only get into what's Alcove 2 now. In the past, years ago, we would try to get down into the experimental areas, but we've been doing a number of electrical upgrades in some of the infrastructure areas, so we are trying to, you know, keep access as far down as we can, but that's one of those areas that, you know, we've had the basic underground, the far end shut down for some period of time just for safety, and other reasons, as we do these electrical upgrades. But, I think you will have a chance to see the science, the work that's underway, and the critical work during the visit.

I want to talk first of all about some of the significant events since the last meeting. One is right now, we're two weeks from what's our fiscal years are October 1, budget is still pending, the administration, we requested 880 million to keep us on track for our goal of 2010. Right now, the numbers we discussed are below that level, but we have to wait and see what that is. So, inside the project, we're doing a continual replanning to make sure we have the right resources to accommodate whatever our budget requests and final decisions are made by Congress. And, it is a major endeavor this year.

The EPA standards, Dr. Chu mentioned that, the July 9th decision by the U.S. Court of Appeals vacated the standards of 40 CFR 197 to extend and incorporates the 10,000 year compliance period. And, then, another one was on June 30th, the Department of Energy, I certified what's called the License Support Network. We submitted that, and that's an accumulation of all the documents prior to that period. On August 31st, the NRC's Atomic Safety and Licensing Board concluded that we did not meet the regulatory obligation to make all the documentary materials available, and struck our certification. So, right now, in the program, we're taking a hard look at the Board's guidance, what it takes to get the recertification done. So, you won't hear me say anything on schedules today, but we're actually taking a hard look at the volume of work before us in that particular area also.

I want to start a level down in our organization out west here. First of all, Ken Powers is my deputy, who you'll meet in time, brings a lot of experience in contract management work at the Nevada Test Site for a number of years, strong business and management administration. Dr. Dyer, who you've met in the past, still Senior Regulatory and Technical Advisor, spends a lot of time on the science oversight and other key areas with the license development. And, then, if you go down to the bottom, several key positions, you're going to hear from Rick Craun a little bit later today, he's my Manager that's responsible for the engineering and design, and has done a yeoman's effort to working with Bechtel SAIC on progressing against the current design and preclosure safety standards. Also, Joe Ziegler in the middle, Office of License Application, the full accountability up through me on the license is through Joe, so over-management of the license and working with Bechtel, and the National Labs comes through Joe.

Also, three other managers there in the areas of

Business Support, Facility Operations is the site, and then the Health and Safety Compliance. And then the other one under Dick Spence, that's Performance Management Improvement, very similar to what you'd see at nuclear utilities, your corrective action program, benchmarking, baselining, other comparisons, the best practices are managed out of that group, even though there's a line accountability, that's our focal point for that area.

Two other areas I want to mention on the right, Mark Van Der Puy, you'll hear me talk later, I have one champion. Even though everybody, including myself, are accountable for safety conscious work environment, Mark is my champion over those activities. I'll talk more on it later. Julie Goeckner just came in recently, has our OCRWM concerns program, that program we make very visible, any employee that can either go to supervisor if they have concerns, have a special program, employee concerns, or use the corrective action program, or a number of other mechanisms to have those dealt with. And, then, last, but by no means least, at the top, Harry Leake, who's my License Support Project Manager.

Let's now talk a little bit about the organization. Most of the resources up through us, I'm the contract administrator for overseeing the Bechtel SAIC contract, the management operating contractor that has responsibility for design and license. About 1,450 resources in that particular area, including engineering, all the administration, support and other key areas. We have two contractors direct to our office. First of all, Booz Allen Hamilton that's a Management and Technical Support Contractor, will bring in a lot of special nuclear experience, engineering, to do oversights and reviews. And, then, also on the right Navarro Quality Services supports our office. Denny Brown, I should have mentioned earlier, is my Manager of Quality Assurance, he supports our office directly, as well as Dr. Chu, an independent oversight of quality for transportation and other areas. We have about 40 people in Navarro that support our office in Quality Assurance, surveillance, audits, assisting in developing the Quality Assurance requirements document, and other key areas.

And, then, last, but by no means least, about 350-- about 300 resources between our national labs that will report up directly through Bechtel SAIC on all the science, test program development, performance confirmation, U.S. Geological Survey, as well as the U.S. Bureau of Reclamation that John Ake will talk to you a little bit later today on, the seismic and design.

Let's talk a little bit now, if I can, to the next slide, about the license application. Again, the current plan is completing that critical science that's been done over the last two decades that relates to the 10,000 year standard. There's been a lot of good work. A lot of our emphasis right now is drawing that work to conclusions. We think it's very important, because even though the standard is vacated, there was work geared towards that. But, in doing those reviews, we're looking out past the 10,000 year period.

Now, this is a chart I believe I've shown in the past. Again, it's not June of '04, it's June of '03. So, on the right there, you have June of '03, where we were on performance and where we are right now in our planning. Key Technical Issue Agreements, I'm going to talk a little bit more specifically about their purpose later, but it's through July, and this date is through right out of my monthly operating reviews, through July of this year, we were at 94 percent complete. However, we addressed and transmitted to NRC the last of those agreements on August 31st, therefore, it was a major accomplishment. We're now 100 percent complete, at least on addressing those Key Technical Issues over to the Nuclear Regulatory Commission. More later on those.

The document itself is the physical preparation of the license, it's the chapters, and as I'll talk later, it includes sections and subsections, it pretty well tracks right against the Yucca Mountain Review Plan prepared by the Nuclear Regulatory Commission. So, there's about 70 sections, or subsections in the license. So, as far as percent complete, we're at 76 percent right now.

Preclosure Safety Assessment, lagged behind significantly for a while because of design. We made some changes in our design back about eight months ago. Rick Craun, I think we briefed some of that at the Amargosa Valley meeting some time ago, but we'll talk more on that today. Right now in Preclosure Safety Assessment, we're about 89 percent.

The Long-Term Safety Assessment, Total System Performance Assessment, right now at 81 percent. Now, that's being held flat for a critical reason. As I'll talk a little bit later, below the TSPA, and really the foundation of the license application are analysis and model reports. That's where a lot of the science is concluded. There's 90 of those key documents which will all be completed during the month of October. So, at the time those are completed, you'll see TSPA go to 100 percent, and that's the runs against the compliance cases.

Design itself now, and, again, that's 90 percent of that amount we feel is required to support the safety analysis and the license. Overall design space would be about 10 percent to 12 percent of final design.

Overall total weight complete at the end of July was about 85 percent. One of the areas I've mentioned, myself and a number of out senior managers have been spending continuously over the last three weeks, and it will complete in the next week and a half, the full review, integrated review of every section of that license of the 70 subsections. With that, there will still need to be a lot of editing, cross-references, all the necessary integration to bring that together. Consistency reviews are underway right now.

A couple other areas that go along with this, though, is a lot more than just the license. A lot of agreements are needed to support that. We're in the process of discussions with the Air Force here on the Nevada Test Range to make sure in time, we have the necessary requirements and restrictions for air flight in the direct area of the repository, which would have to be in place prior to construction authorization and license by NRC.

Also, another major effort underway right now is the environmental analysis in order that the time the license goes over, we can submit our environmental analysis so that the Nuclear Regulatory Commission can adopt our final EIS that we did at the time of site recommendation. So, there's a lot of parallel activities going on in addition to the license.

Let me talk now, if I can, on the next one. Key Technical Issues, this is a summary our people maintained in the project, you know, since August of 2000, and that's the time really when the Key Technical Issues came about, they were defined by NRC as a means to focus on those key aspects of the repository system that are most significant for post-closure performance. We did deal in a few in preclosures, you can see, but most of that effort is towards postclosure.

And, starting in 2000, DOE and NRC held a series of meetings and reached agreement on 293 items for which additional information would be completed prior to submitting a license application. And, as I mentioned a little bit earlier, about three weeks ago, on August 31st, we submitted the remaining 17 responses to NRC, and with that submission of information pertaining to that, the intended purpose of the KTI process has been met, and the process completed for DOE. That's a major undertaking. I've only been on this project for just about a year and three-quarters, a phenomenal amount of effort by the National Labs, U.S. Geological Survey, Bechtel SAIC, my DOE staff, and I can go on and on, and I mentioned some, and I missed some I'll hear about at the office later, but these folks did a yeoman's effort. I think some of those have been shared with the Board in the past. We really built a lot of the technical case, and addressed a lot of the issues that would be a foundation in the license.

Now, that those have been submitted to NRC, we have about 108, I believe, it may be a little higher than that, that have been closed by the NRC, and we'll deal with the rest as we move into the next context of the licensing process, and we have requested NRC for feedback on some of the higher risks. They did a risk assessment some time ago, I guess it was about a year or so ago, and assessed the risk importance of these KTI's, and we're trying to continue to work to get feedback on those, so we can continue to move ahead and do the necessary planning.

Let me show you now the next one. It shows the license itself, and I've showed this chart in the past, I apologize for some of the areas, but there's no way I could make it any bigger on the triangle there. But, this is what a license is. In the upper two boxes are the actual license itself. And, the license application has a section called General Information, it's about 400 pages, it will go up and down as we complete these reviews now. In that section, and these match right against Yucca Mountain Review Plan, there's a general description of the site and the repository, has proposed schedules for construction and waste emplacement to show that ultimately, we can handle the 70,000 metric tons of fuel and waste. It has a physical protection plan, the actual security aspects of the repository. Material control and accounting program, from the time that material leaves, waste or spent fuel, from commercial facilities or utilities, DOE sites or the Navy program, until it comes into our repository and placed in the underground, how do we control how the necessary records and confidence on that particular type of material. Also, there's a summary of site characterization. It's a summary of all the work done over 20 years in the program, all the necessary characterization.

Next area, 4,800 pages, again, that will go up or down, but 4,800 pages with the Safety Analysis Report, which deals with the preclosure, which is the first repository safety prior to closure, and then repository safety after permanent closure, that's all the Total System Performance Assessment. Also, the Performance Confirmation Program. And, then, all of our administrative and programmatic requirements. That's where we put in there, the management structure, the necessary technical and other qualifications required, all of the key areas to manage successfully the license, quality assurance program.

Now, if you go down the triangle from the top down, you can see the license application about 5,200 pages in the top two triangles. But, below that, there's literally tens of thousands of pages of other documents that are required to track right into the LA. I mentioned analysis and model reports. One time, that number was up in the 120 or so, and as it's gone through a consistency team to align to that that's required to build our case in the license, right now, it's at about 90, 91, or 89 as they're being finalized.

Also, parallel to that, all of our design documents, all of the safety case documents that support it, so there's a phenomenal architecture with the necessary design and configuration control that's required at the time the license is submitted, and to maintain that as we're into the defense.

The next one I want to talk about, as I mentioned before, a license is very important. It's one of our critical goals. But, the nuclear culture, getting DOE ready for licensing, we've had a team, actually a lot of work has been underway for the last year and a half, and I'll talk to you about the results of that a little bit later, but on July 27th, I chartered a transition team and moved one of my direct line managers, Dick Spence, that has good experience in the past in nuclear utilities, as well as in DOE and other areas, to actually develop a transition plan. And, the real goal of that was to define the goals, actions, milestones responsible for a successful transition to an NRC-regulated environment.

Some of the key areas being looked at is we've been doing benchmarking for over a year now with nuclear utilities. What are the key attributes of a successful licensee? Best practices, systems in place and business processes to manage, identifying current state and performing gap analysis. And, then, also, lastly, getting ready for inspection readiness. We've had a number of folks in to try to align to be ready for inspection readiness.

Here, I just provide you, it's not by any means all inclusive, but some of the attributes in our benchmarking and other key areas that are required. And, we do continuous assessment about where we are against that. Leadership, you know, having a clear vision, executable strategies in place, team work, as well as individual accountability, making sure individuals are accountable for their performance.

The next area, and probably most of our emphasis right now is into that, commitment to quality and a strong nuclear safety culture. Actions are traceable and defendable. Rigorous industry standard processes are utilized. And, also, that fourth bullet is one that we've made a lot of progress on, I've had a lot of others that are either ex-NRC or others in doing reviews, is making sure we have a strong self-assessment. And, that's a program, as I brought up to the NRC in our last quarterly management meeting. We've made some progress. We're getting better, but we have a ways to go. So, not just using our corrective action program, but having a strong routine self-assessment to say where you are and what further improvements are needed.

And, lastly, clear organizational goals. So, the point I'm trying to make here is we take equal emphasis while we're trying to get a license completed, to make sure we have an organizational structure, and it's not just DOE, it's all of our contractors, laboratory, and that's a major shift when I first addressed you all about a year and a half ago. I believe our progress has definitely been in an upward direction in most all of those areas.

The next area I want to talk about, there were some questions in the past the discipline and the internal structure is aligning, and it continues to align. We've learned a lot as we prepare our license application, but this just shows, and sometime when you use the term testing, I also have to put monitoring and some of that, because we've aligned, and it continues to be defined, right now, eight key categories, including performance confirmation, number three there, design construction and operational testing, but key types of tests that will be required as you move through the life cycle of the repository.

And, to give you an example, in the interest of time, I won't go through all of them on this, but number two, design, construction and ops testing. For instance, the work that we're doing on development of a prototype waste container now, it's the first ones being manufactured at the facility in Philadelphia, Pennsylvania, with that, when that's constructed, we'll do some testing on materials.

Ultimately, you do some remote testing on the welding in there. So, some of those kind of tests and requirements would come in alignment with number two.

Number three would be the areas with performance confirmation. We've talked about that, and that program has evolved and improved continuously. As part of our integrated review, we looked at both the plan and the SAR chapter, Safety Analysis chapters of the license that deal with that. That plan is looking very good right now, even though we're, you know, continuing a few modifications. But, most of the good work is already reflected in there. So, this just shows some of the architecture that's going in parallel to submittal of the license application.

Now, I want to talk a little bit about safety conscious work environment. We've spent a lot of time in the program over the last three, four years, and a lot of increased emphasis over the last year and a half. This is similar to a chart that I showed at the meeting in May back east. But, really, four pillars, and this is our internal alignment to the program. One is management support, and in that particular area, employees have confidence in their managers, a supervisory line, and be able to raise concerns about any fear of retaliation.

The next area is the effective normal problem resolution process. That's our corrective action program, differing professional opinions, to make sure the avenues are open so concerns can be raised and addressed. That program is used very actively. We have hundreds of concerns in the corrective action program. They're dealt with. They come forth for various levels, and our senior managers pay a lot of attention to watch those to make sure the necessary actions are taken. It's not just the timeliness. It's the quality of the action to get the desired effect.

The third pillar there is employee concerns. There's another avenue in addition to going up through your supervisor, you have another program you can go into. And, then, the last one is effective methods to detect and prevent retaliation.

These are very similar to what's been used in the nuclear industry over the last 15 to 20 years. We take it seriously. People are accountable for that. The areas that are in parentheses were areas that we had from previous surveys about a year ago. That was the number we had based on employees having favorable comments on those aspects of the program. 77 percent felt that they had confidence in their supervisory and their line. 58 percent, one of our lowest scoring areas at that time was the corrective action program, followed by 76 percent employees concern, and 86 percent felt that we had methods to detect and prevent retaliation.

Leadership council that I chair that has members of our national lab, Bechtel SAIC, we meet on a monthly basis. The time we set goals for our survey that's actually going to occur in the next two weeks, and the results will probably come out in December or January, and that's the numbers that are up above. Again, corrective action program, we set a goal up to 70 percent, and some of the others, it ranges from 85 to 90. So, that survey, we're going out to our employees in the next two weeks. That's just done every year by an independent firm will do that survey for us, and hopefully I'll have the results by the next meeting.

We use that not just for survey, but to actually take a hard look at the program, where we're at and where we have to continue to improve. It's a continuous improvement, and we take that seriously.

The last area before I summarize, it's not a color blindness test, but it's our internal measures that we look at on a monthly basis. It's an annunciator panel. This is for the one that was done in August that reflects through the July performance data, which is shown in the lower right. License, the design, all the modeling support safety analysis and site operations are in the top boxes of work execution.

All the areas below, including corrective action program, quality assurance, are in the bottom. It's basically a red, a blue, green. Red, yellow, blue means six months of sustained green performance. But, I can tell you when someone gets there, that bar changes, the thresholds change, so they go to the next level real soon. I tell them to enjoy it for maybe a week or two, but the challenge is going up after that. Green means that things are going well, no major issues with it. Yellow are areas of management concern. And, red says substantial concern required.

Now, the ones up top when you look at it, TSPA was based on some schedule issues in the analysis and model reports, so some of that data doesn't reflect the baseline change that we did that allows these models now to be done in October. So, again, I believe in the next month or two, you'll see the ones that are in the red on the top, actually go into at least the yellow and green categories soon thereafter.

The main points that I told our managers is not the colors, it's having clear accountability, understanding what your goals are, managing that, being critical of the issues, and taking the necessary actions to get the desired level of performance. So, we'll have another meeting out here next week. It's not just DOE, it's Bechtel and all the performers on this.

So, that's where I'll summarize for now. There's a lot of work underway, a lot of challenge before us, as I mentioned, and again, we're continuing not just the hard work on the license application, but also the management areas, quality and other areas, and look forward to our continued interactions.

Let me open it up for questions.

GARRICK: Thanks, John. I have one question, comment, and maybe this I should have given to Margaret, but it takes me a little while to warm up. As you know, the mandate of the Board is to evaluate technical issues, but the ability to deal with technical issues is very much dependent upon individuals and capability of those individuals.

As we look at the recent events, the perception of many could be that you've suffered some rather severe setbacks with the court action, with the budget uncertainties, with the information about the licensing support network, and what have you. I didn't see it in this leadership issue that you dealt with, but has there been any impact on people in terms of departures or turnovers, or what have you? Because it seems to me that right now, you are at your most critical period with respect to sustaining high technical capability.

ARTHUR: Good comment, John. There have been a number of challenges. As far as key individuals departing at this time, we've had and continue to have turnover, but as I've told Nuclear Regulatory Commission the other week on an update, I would expect with some of the issues as you mentioned before us right now, we're going to see an increase in our concerns, program, and other areas, and I am starting to see some of that.

The key biggest challenges, we're making major transitions in this program, and one we're in right now is a transition from 20 years of science, we've actually been embarking on this over the last two years, but in the continued science, but also with increase in engineering and license and license and defense.

And, so, the other key areas, we're taking a hard look at our resources right now. What are the budgets going to allow, and the rest, and we're trying to maintain all the key resources we have, but at the same time, we are starting to lose some. And, that will continue. That's a challenge before us. Until I really know what the budgets are, we're doing our best job to plan right now, and the leadership, to get out and visit with folks and tell them what we know and what we don't know. And, I don't know any other way to deal with it right now.

GARRICK: Ron?

LATANISION: Latanision, Board.

John, at least I don't recall having heard much in the past about LSN. Is this something that was anticipated, or is it a new phenomenon, or what is the evolutionary character of this?

ARTHUR: I probably mentioned it. I apologize, I never really got into the details. But, you mean as far as what license support network is, and what it's meant to do?

LATANISION: Yes.

ARTHUR: I mean, it's been out there, and we've been aware of it for years, and I don't know the exact time when it came up. But, there have been critical discussions between NRC, DOE, and other participants in the program, and really, at the purest sense, it's meant to have all the necessary documents in the program, those that are considered relevant and available for electronic courtroom and for other use, so everybody can see all the documentation that's used to support a license, or that information that's contrary to a license. And, so, we've been working very hard over the last year and a half, two years prior to the June 30th certification to get everything from electronic mail, e-mail, to documents, to comment resolution processes, and go through the necessary screening. And, it's a major endeavor, I mean, the level of work that's required there.

Then, we submitted it in June, and then with the certification denied, or turned down, what we're doing now is sitting and looking at the requirements again and seeing what has to be done to complete that process.

LATANISION: Latanision, Board.

So, in terms of time commitment and staff and funding, all this was anticipated and built into the budget request?

ARTHUR: Yes, it has been. And, it's a major resource intensive effort. I would like to believe in today's technology, you could just hit a computer and let it go through and screen everything, but it is a major labor intensive effort.

LATANISION: And, just to follow up, on your Figure 6, is it materially integrated into Figure 6? What role, how does this play on in terms of--

ARTHUR: Good point. Most all the documentation that is in that figure will be one way or the other in the license support network. So, in time, for instance, if you into the system on the website as it is today, and you hit corrosion, you could see a phenomenal amount of data. First of all, you'd probably have thousands, if not hundreds of hits. You'd have to limit the words, the amount of key words to get more specific on the search. So, all the documents are going to be in there so research can be done prior to the hearings, in support of the licensing process.

LATANISION: Thank you.

GARRICK: Henry?

PETROSKY: Petrosky, Board.

Since I'm a new member, I guess I'm entitled to one naive question. Several things you said prompt this. First of all, several of the new Board members are disappointed that we won't be able to go deeper into Yucca Mountain, and you mentioned it's because of electrical upgrading. So, I assume that in this central chamber, and I don't fully understand the terminology yet, but there's electrical conduit, or electrical equipment, there's probably also mechanical equipment, ventilation equipment, and safety equipment, and so forth, and so on. What's going to happen to all of that material? Is it going to be removed before the final closure? And, if not, what about the effects of it on corrosion, for example?

ARTHUR: Let me make sure I answer the questions. First of all, as I said earlier, it was for electrical upgrades. I mean, what we're having to do right now is a series of maintenance that's been waiting for some period of time on what we call our Mine Safety Panel. So, they go into the underground and you'll see a number of those. And, I, too, hope in time, a lot of it's based on where we go on budgets, and the rest. What we're going to be able to do this year is going to drive what, you know, I can open up and what we maintain.

Your other point, the underground lobby infrastructure as currently prepared was set up for really a test program. I mean, it wasn't set up for long-term repository. It was set up to set the initial drifts, to do the necessary site characterization, and really no more. And, so, in time, as we look at the current design, which we can really see right now, and the underground requirements, and also the surface, there's going to be a drastic change out there in time. As we get close to construction authorization from NRC, we're going to have to take out a lot of the electrical. There will be a temporary electrical, and then we'll put the structure that's required for the long-term down there, including ventilation and other key areas.

So, right now, we're doing a lot of transition planning to make sure we look ahead to what it has to be like when we get into long-term construction. And, Rick can probably talk about some of that--he's nodding yes, so that's good--in his presentation, but the good thing I can show you, and we'll make sure you see it Wednesday when you're out there, you can take for the first time an overview of what the surface is where you're standing, you know, on the tens of acres that we have out there right now for the surface facility, and now you can get a real overlook at what our design looks like and how big it is in time, and it's a very large construction job, a major transition is going to occur out there.

GARRICK: I have--do you have another one?

PETROSKY: I just wanted to follow up just a bit. My question was also what is going to happen to all of that infrastructure when there is permanent closure? Is it going to be entombed with the nuclear waste?

ARTHUR: Rick will cover more specifics, but a lot of that infrastructure will be pulled out as we come back from the underground. I'm sorry, I was talking more of the transition. You were talking long-term. That will be pulled out.

GARRICK: I have Board members Duquette, Abkowitz, and citizen Nelson's and Parizek. So, let's let Duquette.

DUQUETTE: Duquette, Board.

You opened the door, so let me ask some questions about the container. You indicated that a test container is being built and will be ready for testing. The questions I have are several fold, but all tied together, and it's what will the container consist of? Is it a full sized container with all of the components that we expect to see, and what tests are you going to do?

ARTHUR: Okay, first of all, it's a first prototype, and we're building it out in Pennsylvania. It's a full sized waste package, and the date I have still is late summer of 2005 is when we're planning to have it. At the time, and, again, everything, knock on wood, depends on budgets and what we have in our priorities in the program. It will probably be to take that out to Idaho or another facility, and actually then start demonstrating some of the welding. But, the first one right now is to get the construction of that package down so all the quality control, essentially the construction development process can be done. So, that's where we are right now, and then once that's done, next year, we'll start some testing, and it principally will be welding.

DUQUETTE: Duquette, Board.

I presume you'll keep the Board apprised of the progress and how that's coming?

ARTHUR: Definitely will.

GARRICK: Mark?

ABKOWITZ: Abkowitz, Board.

John, I wanted to focus on this EPA 10,000 year safety threshold and the fact that that's been kind of thrown into some question at this point in time. The program that you present to us doesn't seem to appear that it's blinking an eyelash in terms of the focus and the time frame under which a documentable license application is being considered. So, I can only conclude one of two things: either that you believe that the 10,000 year threshold will eventually be reestablished, or that you have done enough safety analysis at this point in time that you believe that the current design is safe enough that 100,000 years, or perhaps even beyond that. Could you comment on that, please?

ARTHUR: First of all, you know, the work we've been doing over the last, you know, four years as it went from site recommendation on, first of all, was geared at 10,000 plus, you know, and we had a lot of information there. So, what I said earlier is we're drawing our conclusions on that. Coming this far, it would be hard not to draw your conclusions and build your case, your defense in depth, at least to where you are in 10,000 years.

The other point I did mention is we're also taking a hard look at all those analysis and model reports to say if you were looking out at a longer time frame, on the orders of hundreds of thousands of years, how many of those would really be variables at that time. And, so, you can look at things like climatology, you can look right in the license application now, and you can see studies and information that goes out to, in some cases, 800,000 years. So, we're taking a hard look at both right now, but also we're taking a hard look at the options, where we are, and the rest. And, so, the commitment we've made before is we have a goal that's December 2004. We're still working towards that. At the same time, we're doing a lot of internal legal, technical and other analysis.

GARRICK: Nelson, Parizek, Hornberger.

NELSON: Nelson, Board consultant.

My question is prefaced perhaps best on Slide 9, although several of the points are raised throughout. And, we've had these issues before for the Board, before the

Board. And, they may be even made stronger because of maybe some uncertainty about exactly what the regulatory period might be, and relative importance of different kinds of testing, as you've identified this. I'm trying to map these areas here onto your organizational structure, and trying to see exactly what's happening. Long-standing, we've been interested in the tests that are ongoing, planned or unplanned, like the bulkheaded off areas that were effectively planned science in some ways.

I think the importance of those is only increasing, and at a time when monitoring is becoming more difficult, and understanding what's happening is also becoming more difficult. We've asked a lot about performance confirmation and what happens, how the concept for performance confirmation evolves. At one point, it was all encompassing, and it's now parsed to a very specific framework of the performance confirmation plan relative to the design. We've got the Science and Technology Program sitting over there at Number 8, which is now parsed into two parts, part on the long-term barrier performance, and then another part on long-term operations. And, I assume this is Budnitz's program. But, it's really focused towards improving performance, primarily adjudged by TSPA calculations, but it's really focused towards cost effectiveness, performance effectiveness, and how it proves out.

And, the standard question that we've always asked in addition is what about the science, just wanting to improve the understanding of the science. And, so, now I see 1b sitting over there that's called DOE elective testing, which seems to get after some of those areas of uncertainty and conservatism, improving the understanding of the science. I don't understand how these all fit together. I don't understand whose rolling up all of the understanding of the science, and whose going to make that DOE elective testing decision in competition with all of the other decisions that have to get made.

So, it's a rolling question, but can you--I prefaced it, because I think a lot of the Board members don't know that we've asked these questions before. So, the sense of trying to make sure that the science is integrated, when some decisions are made by the contractor, some national labs, some here DOE, some Washington DOE. Where is it coming together?

ARTHUR: It's a good question. I'd recommend as to the future, and it's obvious that the Board's determination of when to come in and brief you with more specifics of what rolls up in each of these categories. You're right, Priscilla. I mean, when I looked at it, I said I don't want to have a bureaucracy here where you have so many different boxes, you lose control of what you're trying to do.

I truly believe performance confirmation right now, and that's based on, you know, my dealing with a lot of our experts, and I know Margaret has been heavily involved in that, and others, we believe truly it's maturing to where it will meet the intent of the regulatory requirements for that kind of program.

Some of the other areas you mentioned, at the time license is submitted, and even before that as we move into the next fiscal year, you've got to have in a program like this a lot of rigor on what's continuing, as far as tests, and what's not. We're right now in the process for the next fiscal year of, I call it baselining, but actually making decisions on those studies, both continual, new ones, and those ones that are terminated. A lot of those will be in that Level I area there.

And, so, the management aspects, to go back to where the decision is made, we have a close liaison between my office and through Margaret's office, John Wengle, Budnitz, and the folks that do the integrational long-term science. But, a lot of the decision of what's in and out is occurring between our office and Bechtel and with national labs, and what we're trying to do is look, we're going into a new era in the program, but also making sure we have flexibility for the future. And, I'd recommend sometime we come in and just give you a little more specifics so you can see the suite of tests that continue right there.

NELSON: Just to follow up, Nelson, Board consultant, that that be thoughtful, you know, integrating, because I think there's always been on this project a long-standing wish to have someone in whom the science is constantly being integrated, like a chief scientist of some sort. I mean, that continues, and if anything, it continues even more importantly as the prospect of the importance of longer than 10,000 years may be elevated for the project.

So, we're not hearing from Mark today, so we're not getting updated on the science. But, there are certain areas of the science which I don't know whether they actually are considered part of performance confirmation, whether they're in the Science and Technology Program, or if they're DOE elective testing that we thought was very important, including some of the hydraulic conductivity testing, and certainly the thermal testing in the lower lith where so little really has been done. So, I don't know where those are, and I think it's really important that the Board understand where those are and who's making the decisions.

ARTHUR: One point, if I can add in, you reminded me, you said, I mean, there's a very close integration to the working level between Mark Peters, Russ Dyer, Bill Boyle on my staff who works for Joe Ziegler, I believe made a presentation before to you. I mean, those folks are at least on the federal side, are the ones very close to some of the decision making, but ultimately is reporting up through Margaret and ultimately to, you know, myself as we make decisions and we move into licensing. And, a lot of this right now, I'll tell you, you have to look ahead and say where are we going to be in this next year to keep the critical path activities going, and I include continued science and tests into that, as well as license support network. But, again, it's a big challenge.

PARIZEK: Parizek, Board consultant.

I want to follow up on that same theme, is whether or not there will be sort of a document provided to the Board for review, or just a briefing on the nature of the confirmation testing plan. Bodvarsson, more than a year ago, gave a detailed account of what could be anticipated in that, and we're not sure how all of that's played out. So, again, I would just say will there be a document in advance of the LA submission that could be reviewed?

ARTHUR: We could probably give an update briefing or information, whatever is required, because I'm trying to remember, when was the last? You mentioned it was last April?

PARIZEK: More like the January time frame.

ARTHUR: It's changed quite a bit, so we would welcome an opportunity to update you on that.

PARIZEK: Parizek, consultant, again.

As far as the aircraft safety assessment, is it more than just talking to the Air Force and saying don't go there anymore versus what the implications might be of an accident that could occur based on the three accidents that have been reported?

ARTHUR: There's a lot of evaluation underway. Obviously, you're taking a look at all the data, and we do have, I can't say enough that we have a very, very strong liaison with the Air Force, and so sharing of information on previous accidents, also mitigations that occur. So, we're looking at, you know, the probabilities, also design itself of our facilities. And, so, there's a lot of evaluation underway.

When I mentioned earlier about a memorandum or some agreement, it's just to set an agreement in place that at the time the construction authorization license is granted, that we'd have the necessary air flight restrictions in that limited area. I want to be real clear on that. It's just that limited area of the Nevada Test Range, because the Air Force has a very critical mission out there. They don't want to have an impact on us, and we don't want to have an impact on them.

PARIZEK: Parizek again. In terms of update on seismicity, volcanism, this will be all part of the program, and volcanism, Wednesday, Thursday coming up, so the members will be weighing in on that.

As far as the Chlorine 36 issue, when is it--first of all, to resolve that is a long-standing concern of the Board, because of the credibility of the program dealing with science issues that you'd like to put to sleep and say, well, either we can use the data, we can't, or we agree, we disagree, whatever it is. But, getting people underground to be able to do the sampling to carry on the experiments that were being talked about, do you have a time frame for that?

ARTHUR: I was looking to make sure--Claudia will talk about the Chlorine 36, and I'm going to talk about the underground.

NEWBERRY: Newberry, DOE. Let me just insert quickly. We're waiting to get underground to do the Chlorine that we need to do, so that UNLV can go ahead and do their testing, and that's dependent on budgets, as usual, at this time of year. So, if they get underground and get the samples that they need, they should be progressing in FY '05.

PARIZEK: Thank you. One other one about KTI's. Are there any of the KTI's that may be impacted by more than a 10,000 year time standard as you kind of look ahead and say are there any of these that might backfire on us, having closed them or having submitted them, that all of a sudden now they may have to be reopened because of the possibility of extended time? It's just another thing to be worrying about at this time, say, well, we'll deal with if it comes to that. But, right now, it's the two fortune cookies, and we don't know if it's 10,000 or more at this point. You almost have to have a contingency plan to deal with this?

ARTHUR: We're taking a hard look at everything, including some of the KTI's right now. I mentioned earlier about, you know, we're looking past 10,000 years analysis in model reports. Clearly, a lot of the Key Technical Issues supported decisions there, and long past that. So, we're taking a look at that right now. I mean, I don't want you to think we're just looking at the analysis and model reports, it's KTI's and everything.

PARIZEK: Thank you.

GARRICK: You might want to check one of those fortune cookies here a little bit later.

HORNBERGER: Hornberger, ex-civilian and member of the Board.

John, I wanted to follow up on this interesting question of compliance. So, in the past, I know there's been some criticism of some potentially overly conservative assumptions made in TSPA, whereas, these might not have any impact on 10,000 years, but they might actually impact the calculated dose beyond 10,000 years. Now, you indicated that, on your last slide, that TSPA was pink, because you're at 81 percent, and you're going to wind up at the end of October, and part of that, you indicated was that you had to do compliance runs, which one can infer means somebody looking at the TSPA results against some presumed compliance regulation.

And, I guess my question is is this scramble in part going back and redoing some of the analyses to try to get a better handle on the beyond 10,000 years, or are you making inferences as if Part 63 remains as you understood it in June of this year?

ARTHUR: Well, first of all, when I said the process on TSPA, I didn't today, and probably I should have left it in my original presentation, in the past, I talked about what's called a Regulatory Integration Team that we put together well over seven months ago when we knew we had to standardize the review of all those analysis and model reports. So, one set of eyes looked at everything for all the 90 analysis and model reports. In doing that, we also had a number of quality transparency issues we were trying to get resolved, and indeed, we've made good progress. So, when I talked about the analysis and model reports getting done in October, it's to come out and make sure all of those stand on their own, to have the necessary information and conclusions.

So, when I said that final TSPA run, that was to draw the conclusions, again, currently at the 10,000 year standard is where we're making our run at that point in time. But, as we go through all of our analysis, as I said earlier, we are taking a hard look at what would be out, you know, at a longer period of time, which one of those analysis and model reports do play a major factor out past 10,000 years. So, it's purely scheduling reasons right now to make sure that we have it done to the right level of quality, because I can't say enough, and having actually now been personally engaged in not a line by line review of the license, but just a section by section, I and some of our senior leadership. There's a lot of phenomenal work in there, but there's, you know, integration that's required to bring it all together, and that's what we're working on right now.

GARRICK: Any other questions from the Board? From the Staff? Yes, David?

DIODATO: Diodato, Staff.

I wanted to follow up on some of the ESF questions. First, I appreciate your apology about the Board not being able to get farther into the ESF, because I think it's an unfortunate missed opportunity to take a look first-hand at a lot of different science that the program has done over the years, many significant experiments.

And, furthermore, I think that my understanding is it has a broader impact, which may be of more significance in terms of actual ongoing science, which is now not ongoing, basically. And, the Chlorine 36 example comes out in particular. It's my understanding that in this past year, that researchers have not been able to gain access to the ESF to get their samples because of the safety concerns of the tunnel not being safe because of the infrastructure now.

So, I heard you talk about long-term ESF will become kind of a white elephant, because you have to get on with the construction plans, and that's not of interest anymore. And, then, I also got the sense that in the short-term, you're planning on upgrading the electrics, and that sort of thing, and getting it kind of safe for operation. So, first, do you plan to reopen the ESF's to make it safe for scientists to go back in there?

ARTHUR: Well, right now, first, a couple points I want to clarify. First of all, the intent is to look at what science is required in there and continues. Even as we go into repository construction, it's always my vision a certain amount of science would continue in that area. And, the area right now, you know, first of all, we're making sure the necessary electrical upgrades occur, again, budget permitting. If not, it could have a bigger impact. Again, I've got to wait and see what the budgets give me in order to make a decision, and everything has got to be aligned at the right time.

And, so, we're taking a hard look at it, and I fully understand the importance of those tests. It's on my personal screen. I'm going to make sure if we can, we maintain the access. But, right now, I just can't open it up like it was at one time for tours all over, because for a while there, some of that was limiting some of our workers' ability to do the principal thing to get it maintained.

And, then, the other point, I do regret, because I thought it was pretty open for some period of time, that we only could go into Alcove 2, and I hope that my announcement today wasn't a surprise, because I myself had to go through a two hour training, and anybody else could do that, and you can get access under controls. And, so, that is an option. It's just we didn't know that that kind of time was available to get everybody trained the same, you know, respiratory training and things that I had to go down in the underground.

DIODATO: But, for a scientist that would want to go in, there is, according to you, now an opportunity, they can get training?

ARTHUR: I'm going to take a look when I get back today, back to the office, and just really see, because there have been certain restrictions in the underground. But, right now, I've just got to wait and see what we get for budgets moving into the next year, and then make some decisions. And, some of them are going to be hard decisions in this program, because we aren't going to be able to keep everything as we currently know it underway.

DIODATO: Thank you.

GARRICK: Any other questions from the Staff or the Board or the consultants?

(No response.)

GARRICK: Okay. Well, we're doing very well, and I think our program calls for a break right now, so we'll so do it.

(Whereupon, a recess was taken.)

GARRICK: Let's come to order, please. We're now going to hear from Rick Craun. He's going to give us a report on the repository design for the license application.

CRAUN: Thank you for this opportunity. I'm Richard Craun. I'm the Acting Director for the Office of Project Management and Engineering. I'm going to give you a summary or overview of the repository design status.

As John Arthur pointed out, the license application safety analysis is being developed now. It's really broken into two parts, a postclosure portion and a preclosure portion. The discussion I'll be having today will be addressing the preclosure portion of that safety analysis report.

I've also broken the briefing, or this information exchange, into three parts, an area covering the surface facilities, subsurface facilities, and waste packages. If you'll notice or count the number of slides I have, I have far more slides than what I can go through in a reasonable amount of time. The intent is to give you an overview. Some of the slides I'll go through fairly quickly. I'll make a few key points on those, and go on, but will provide, I hope, the opportunity to put information on the table so you can come back and ask questions in those areas that you're interested.

Now, let me see if I can do this with a pointer here. What I wanted to do is basically this is the repository, the subsurface portion, this is Exile Hill right here, the North Portal Ramp, then to the South Portal down here. The subsurface portion of the repository is designed to be developed in phases. The initial phase of development will be the Panel 1 in this location right here, Panel 2 in this location, Panel 3, and then Panel 4.

For initial operations, Panel 1, we've designed it so that after three emplacement drifts, we could actually start emplacement operations. The balance of that panel would be constructed as we're emplacing. To give you a general overview, and I'll go into more detail as I go forward, this is the existing, part of the existing road through here. Actually, the existing road, for those who have been out there, comes up here, and then goes down to the

South Portal. This would be all of the new surface facilities that would be added starting from receipt of the national conveyance, through our nuclear facilities here, which I'll come back to in more detail. Once processed, the material would so subsurface to the emplacement drift, or to the aging facility. Currently in the license application, we have 21,000 metric tons of aging in the design, with contingency for 19,000 additional tons.

What I thought I would do is just start out and give you a brief overview of the types of materials, or actually the transportation casks that we would receive at the repository. I've depicted here just typically, a rail type cask, that would be a Part 71 license cask, and a truck conveyance cask.

As we will get into later in this discussion, the rail casks predominantly in our preclosure safety analysis and in the truck casks, we're worried about drops of those casks and/or heavy loads being dropped onto those casks. The rail cask typically is about 100 to 165 tons, and the truck casks are more in the 24 ton range. 27 feet length on the rail, 11 feet in diameter on the rail cask.

I'm going to spend a fair amount of time on this slide. Let me talk you through the operations. The operations is important to us on the surface facilities because it is the combination of the external hazards, seismic, tornado, and also the internal hazards of our facility, which we are capturing in our preclosure safety analysis. So, the operations, how we go through the evolution of accepting the national transportation conveyances, what we do with those, and the sequence of events all plays into then the preclosure safety analysis and those event sequences that we need to either prevent or mitigate.

Let me start with just the receipt. I'll walk you--well, let me point out what the facilities are. This is Dry Transfer Facility 2, Dry Transfer Facility 1. This is our Canister Handling Facility, and our Fuel Handling Facility. Earlier this fiscal year, we had just these two nuclear facilities. We added these two facilities to ensure operations capability in 2010, and to accommodate cask handling in a cleaner environment, and I'll come back to that shortly.

You'll also notice here--well, let me point out one other facility. This is our transportation cask receipt and return facility. It's actually these four facilities, one, two, three, four, are our primary processing nuclear facilities. This is also a nuclear facility in that in there, we have to make lifts of the national transportation, or of the casks, off of their national transportation conveyance, off the rail, or off the truck, and put them onto a site specific rail transfer system, which allows us to receive the cask at this point, and then through this site rail transfer system, we can then bring that material to either of the processing facilities themselves. So, as a result of that lift, without the impact limiters, that's also classed as a facility that's important to safety.

Let me just walk you through briefly how we would receive material, and how it would flow through the surface facilities of the repository. Our main receipt location is down here at Gate 30. There is where we would make an initial inspection of the national transportation conveyance, do some initial surveys, radiological surveys. And, then you'll notice what appears to be a wide blue section, and that would be our rail yard. There, we have buffers capability for approximately 50 rail and/or truck.

Let me back up and speak momentarily about some terminology. Buffer zones are those locations where we will have material available for the processing facilities. It's entitled a Buffer Zone here on initial rail receipt, and we're also buffering in this area here on the site rail transfer car system. Those buffer zones will have the national conveyance system still in its Part 71 configuration. Part 71 is transportation. So, we will maintain the impact limiters and personnel protective barriers in this location, and also in these locations.

Once then brought into the nuclear facilities, either the Fuel Handling Facility, Canister Handling, DTF, Dry Transfer Facility I or II, then in fact those impact limiters would be removed. Any sort of interior building, kind of capacity, a surge capacity would be called Staging, it's Buffering out here, Staging internally, and then we have Aging Facilities.

Internal Staging would accommodate operational issues inside the surface facilities, and also those operational perspectives would be, we'd have both thermal management taking place in our aging, and also operational considerations. So, that, if we wanted to campaign BWR, or boiling water reactor, or pressurized water reactor materials, we can actually buffer, stage, and use aging to help manage that.

Now, there's a color coding system here that we've incorporated into our surface facilities, and I need to go quickly because I've got a lot of material here to cover, but the color coding is looking at those facilities and/or support facilities necessary for initial nuclear operations. Initial nuclear operations can be supported with the blue, it could be expanded then to include canister handling, which would bring these two facilities on line, and then our production capability would come on line here. You can see how that ties to aging, and also aging capacities up here.

So, we really are looking at not only in the subsurface, but in the surface facilities, a staged or progression of operations throughout the life of the repository.

I'm going to go ahead and go forward. There was a couple other points I wanted to make. I'm sure they'll come up in the questions.

Let me now digress for a brief moment on how we take the operations and look at our preclosure safety analysis, because it's really the marrying of the design in the preclosure safety analysis that we're in the process of doing now in the development of the license application.

We've identified all the internal and external hazards. We also are looking at the human induced event sequences. After those hazards are identified, we go through a series of analyses to determine the frequency of those event sequences. If they're likely to occur within the life of the surface facilities, which is a 50 year life, one or more times, that's considered a Category 1 event sequence. If they are likely to occur--or at least one chance in 10,000 chances of occurring, then, in fact, that would be a Category 2. If it's less likely than one chance in 10,000, then it would be beyond Category 2.

That's very important from the preclosure safety analysis because it is our event sequence categorization that we then take to our dose allowable, our consequence calculations, so we then go from an event sequence frequency calculation, to a consequence analysis. The consequence analysis looks at Category 1. We have several different combinations of exposures we have to look at, but predominantly, we have worker, radiation worker exposure limits, 5 rem. We have public on-site, 100 millirem, and then public at the boundary of 15 millirem. Those would be our limits associated with Category 1 events. Our Category 2 event limit, sequence consequence limit is 5 rem at the site boundary.

Now, once we've identified the event sequence and we've identified that there is the potential of a dose consequence associated with that sequence, we then look at whether or not we're going to try to prevent that event sequence or to mitigate the consequences of the event sequence. Once we've gone through that effort, we've captured then all of these design parameters into a document that we call the Nuclear Safety Design Basis. Best in the interconnection between preclosure safety analysis and the design itself.

Let's go to the next slide. Predominantly, the repository is designed from a prevention strategy. We don't allow, we're trying to prevent or reduce the probability of heavy drops onto either the waste package. We're looking at the structures--oh, excuse me, let me just go to the second bullet. Those structures, systems, and components that we credit for either reduction in probability from either a Category 1 event to a Category 2, or from a Category 2 to beyond Category 2, those systems that are credited in either the structure, systems, or components that are credited in that probability reduction are classified as important to safety. Those structures, systems, and components that are categorized as important to safety, we will apply our quality assure program to those components.

Currently, our Category 1 event sequences are being driven by the number of fuel assemblies that we're going to have to lift. For the 70,000 metric tons, approximately, we'll have a little under a quarter of a million fuel assemblies that we would have to handle through the surface facilities. Now, each one of those fuel assemblies is projected to be handled more than once. An assembly can come from its national conveyance cask and go to a staging internal to the building, come back, go to aging, come back into the facility, go to a staging rack, and then placed into a waste package.

So, for the purposes of the preclosure safety analysis, we've multiplied approximately a quarter of a million assemblies that we have to handle by a factor of four to allow us room to handle those assemblies more than once, even though we don't anticipate handling every assembly that many times, it's simply the number of lifts that are driving the probability of our Cat I events, Category 1 events.

Category 2 events, which I'll get into, defining them, I think, on the next slide, are associated with the handling of casks, canisters, and waste packages.

Next slide, please? The Category 1 event sequences that we have today, we have two event sequences associated with Category 1 for all of our surface facilities. The Category 1 event sequences only apply to those nuclear facilities that handle the assemblies themselves. If it's a canistered process, these event sequences do not apply.

The first is a drop, it's a fuel assembly drop onto a second fuel assembly would be one of the Category 1 events. The second Category 1 event is the bumping or collision of a fuel assembly into a stationery object or structure.

We have about 30 different types of Category 2 event sequences associated with drops of different components. We've bounded in our preclosure safety analysis all 30 of those by addressing three Category 2 event sequences. The first is a drop or breach of the transportation cask of 74 boiling water reactor or 36 PWR assemblies. The second one is a drop or breach of the transportation cask with high-level waste. And, the third is a drop or breach of a Naval canister.

And, if we could go to the next slide? Actually, I don't know if you can do this, but if you can have one go to the next one forward? There we are. I thought it might be easier to walk you through, since the event sequences, as I indicated earlier, are very tied to the operations of the facility, what I wanted to do, this is our fuel handling facility. It will be one of the first assemblies brought on line. I wanted to walk you through in a little bit of detail associated with the sequence of operations. These operations are very similar, but of lower through-put rates than what would take place in the canister handling facility or in the dry transfer facility.

There are a couple of operational evolutions that this facility will not be qualified to perform. One is the handling of a multi-canister overpack, and the other will be the cutting of a dual purpose canister. If, in fact, we receive dual purpose canisters, Part 71, Part 72 licensed canisters from the utility, this facility has no cutting operations in it. Those cutting operations I'll point out later when we get to the dry transfer facility in the dry transfer facility.

The other thing I should probably indicate, the fuel handling facility is unique in that it is not attached to the SRTC's, site rail transfer cart system. It receives all of its material on the national conveyance system. So, for example, a national conveyance cask and/or a waste package would be brought in through the rail yard, the buffer rail yard, into this facility. What I'll do is talk you through the operations of this facility. What I'm going to get you to is this is the primary fuel transfer cell area right here. I'm going to walk you through the events quickly to get you into this point where you would have a waste package here, a national conveyance cask here, and a site specific cask.

This facility does have staging capability, but its staging capability is done via a site specific cask that would be able to go to aging and/or it could stay here and we could off load it to a waste package.

We bring in a national conveyance cask initially. We would take its impact limiters and personnel barriers off. We would up end that cask, bring it into here. We would sample the gases of that cask to see if there's been any damage or degradation during the shipping process. This is the subsurface, this is the waste package transporter. It would not be here. This would only be brought in as we were getting ready to bring a waste package out.

So, if you can imagine this not being here, we would then bring the national conveyance on into this area. We would finish unbolting the lid. And, if you look at the color coding over here, cask operations is red, so I showed you both of these, so that you would bring the cask into the center facility. The numbering here identifies the types of operations we would have for the cask. The blues are for the waste package. The MSC, the acronym stands for the MGR site specific cask, it's kind of a long acronym. But, anyhow, this would be our site specific cask, shows where some of the samples would be located. So, you can jump back and forth between these two however you would like to.

But, anyhow, we'd bring the national conveyance cask in here. Now, once we up ended it back here, we would place it on a little trolley cart right here and bring that trolley cart on into the system. If necessary on the cask, it would be brought into the center station here. If, in fact, we were bringing in a waste package, let me just bring in the waste package, we would bring it in on a rail car. That waste package would be lifted in a horizontal position, and we would add the trunnions to that waste package out here in this location. Once the trunnions were added to the waste package, were installed on the waste package, and I have a slide later on that will show that, we would then go ahead and up end it, place it in one of the carts, bring it over here, and deposit it over here. We would also do the same type of operation on a site aging cask arrangement.

So, we would eventually get casks and/or waste package and/or a site specific aging cask here. We would start the waste transfer evolution. Each assembly would be picked up and either placed into a waste package or into a cask, depending on the thermal criteria that would be applied to the waste package.

I'll jump forward. Once the waste package is loaded, I have a later graphic that shows the inner lid and spread rings. We would install the inner lid in the transfer cell, and the spread rings associated with that, so that now as we bring that waste package out, if we were to have a tip over and a slap down event, where the waste package were to fall over, we don't have an ejection of the assemblies that are in there.

It would be transferred to a cart to take into the waste package welding area. This welding equipment we're now currently developing up in Idaho. The weld cell and all of the facilities, be it fuel handling facility, canister, or dry transfer facility, they're all the same, so that technology that we would use in one would be the same in the others.

Once the waste package is welded, it's brought out. It's brought down over to a down ending device. It would be down ended onto its emplacement pallet. From that point on, every time we make a lift of that waste package, it's on its emplacement pallet.

Once on the emplacement pallet, the trunnions will be removed, and, again, I've got a graphic showing what those trunnions look like, it would then be lifted from the pallet, via the pallet, placed onto the waste package transporter bed, into the transporter itself, and then it would exit the building and go underground.

I'm trying to keep an eye on the time. Let's go ahead and go forward to the next slide. Both of them can-- have them both be this. I'll jump this one back. Now, what I tried to do is look now in a different way, the operations of the fuel handling facility and how that translates into preclosure safety analysis, and components that are important to safety. Let me just go through some of these quickly.

We have the structures that are for confinements, so our tornado missile barrier protection is on the outer wall. I've got confinement here in my Zone 2. My Zone 1, ventilation system, would be here. I have one active mitigation system so far, is the HVAC, that's associated with the mitigation of the consequences associated with a fuel drop and/or collision. In the primary zone, that ventilation system has a four hour mission time that has to perform to filter that primary zone. The supporting, we have an HVAC electrical that supports these air handler units that will actually get that air over to the HEPA filters.

You can see the different types of drops that we considered in here, the main cranes that will be lifting the waste package and/or the national conveyances will be designed to not drop, to be very reliable. So, from that reliability standpoint, they are important to safety for us.

Let's go ahead and go to the next slide, try to speed up a little bit here. This is the canister handling facility. Basically, the material is brought in through this manner. This facility has no Category 1 event sequences. It's only a Category 2, national conveyance cask that we've brought into here, would only have canisters. Canisters would be high-level waste, DOE spent nuclear fuel, Naval and commercial. Those canisters would be transferred into their respective either a waste package and/or for example, on a dual purpose canister, if it were brought into this facility, it would go into a site specific aging cask and be taken out to aging.

Once loaded, we go through the same sort of process, take it over to the weld cell, weld it up, down end it, take the trunnions off, put it on the bed plate, and take it down underground.

Let's go to the next one. This is the dry transfer facility. It basically has all the same operations as the fuel handling facility. We've added some capabilities as far as waste package cutting, if we need to cut a waste package here for whatever reason that we may have, or a dual purpose canister cutting would be taking place here. Let me back up. We bring material in through this direction, either Naval and/or commercial. We prep it. We bring it over. This is the main fuel transfer cell itself. It's a two ported cell, being able to place an either waste package here or here. We do have some staging capability at this location in this facility.

Unique features with this facility, as I've already indicated, we have dual purpose canister cutting, so that we could cut the dual purpose canisters, bring them over to a port here, off load the assemblies from a dual purpose canister into waste packages over here.

This facility also has remediation capability. The fuel handling facility and the canister handling facility do have remediation capability. We have more extensive capability in this facility. We have a pool area here, and a dry remediation location here.

Our weld cells, waste package closure cells are located here. We have constructed for four. We will outfit three. Capacities of the fuel handling facility are about 40 waste packages a year. Canister handling is about 180. And, the dry transfer facility is also about 180 waste packages a year.

Moving on quickly to Slide 16. The surface aging, we're really wanting to use as much of the existing technology, 72 technology, that's available. These are images, actual, of equipment that's utilized at the utilities, so we're wanting to, as much as possible, bring into the design of the surface aging equipment, as much of that license technology as possible.

We do have a different licensing basis, 63 is different than 72. Even for our aging facility, we would have to address items that they do not have to address under Part 72. We have identified, if I recall it, about four systems that have seismic values similar to what we have at our surface facilities. So, some of that technology can be imported to the repository fairly straightforwardly.

I'm going to go quickly, and I'm trying to hurry. Surface aging pad, whether it be the thousand metric tons or this is a 5,000 metric ton representation, each of these is about a thousand metric tons. Horizontal capability at this end, vertical in this area here. Those would be replicated as many times as necessary. Again, the license application that we're submitting, that we're preparing now, addresses 21,000 metric tons. Analytically, we've analyzed it for 40,000, but the license application is for 21,000 metric tons.

Go forward to the next slide, please? A quick overview. I've covered most of this. Again, this is Panel 1, 2, 3 and 4. The first three drifts of this would be what we would be needing for surface operations to commence, and subsurface operations to commence, along with the appropriate ventilation system, about 41 miles, 11 to 13 percent contingency.

Subsurface emplacement. This is the transport locomotive. This is the transporter that I showed you earlier. Even though it shows the waste package is over here, it's actually right there. The waste package, it would be picked up via its pallet by the gantry, and emplaced in an emplacement drift. This is just a representation of what that emplacement drift would look like. Those items that are important to safety, ITS, those items that are important to waste isolation are ITWI.

At the time of closure, we would install a drip shield. That would not be during the--so, it has no ITS function, because the operations, preclosure operations, are completing, or ending, going to postclosure operations.

I'm trying to save some time. Let's go to the next slide. The waste package, it is both ITS/ITWI for several different reasons. This is the inner lid, the spread rings that I was talking about, the trunnion collar that's attached to the waste package, and then removed before emplacement.

Next slide. The drip shield that would be installed at the end of the operations period.

With that, I'll open it up for questions.

GARRICK: Garrick, Board.

I wanted to ask one question about the criteria that you're using for the design. I can imagine three kinds of scenarios, throughput scenarios. One that would be the nominal scenario representing what you would expect to happen under conditions of normal operation. The other would be a range of throughputs, including the maximum that the design could accommodate. And, then, the third category, and the one I'd worry about maybe the most is throughputs in which you have events, accidents, incidents in bottleneck positions, and to test whether or not this is really a parallel system, or a highly linearized, or what. Can you comment a little bit about the criteria, the underlying throughput scenario criteria that was employed?

CRAUN: Well, some of the throughput criteria is driven by Part 63 in our preclosure safety analysis. For example, on the calculation of normal dose, we utilized the normal throughput, 3,000 metric tons a year. For our event sequence, we're using the maximum, which is 3,600. We'll be taking that and lifting it up to 20 percent beyond what are our expected throughput capacities for the entire surface facility in total, to be used in our event sequence.

Our event sequences are being driven, are utilizing the maximum. We're currently looking at, for example, as we continue development of the weld closure cell up in Idaho for the waste package, we're looking at the bottlenecks associated with getting those waste packages into the weld closure cell, the equipment, so that we have what I would consider to be a local equipment throughput. We have facility throughputs, and then we have an overall surface repository and combination throughput that we're looking at, actually all four of those.

GARRICK: Has the design gone through many revisions as a result of looking at the different throughput scenarios?

CRAUN: Actually, it has. In fact, that's why I think I mentioned early, that in fact we've added the canister handling facility and the fuel transfer facility. We wanted to be able to get an initial operations capability, with some lesser amount of throughput capability. The dry transfer facility has, we've completed, I believe, three or four value engineering studies, looking at ways in which we can improve or optimize the design of that, how we might look at improving that configuration. And, in FY '05, we have two or three more value engineering studies that we would look at, optimization, or subtle improvements of the dry transfer facility itself.

GARRICK: Do you think you really know where the bottlenecks are?

CRAUN: Not all. No, I think as the design right now, we're at about 8ish to 12 percent complete in the design. As we get into our detailed design, which is more like 30 percent, we'll find more bottlenecks. We're still integrating the preclosure safety analysis with the design, and we're getting some interface issues there identified now, and I would expect that to go on as we go further and closer to operations, I would expect operational issues to come up, yes.

GARRICK: Questions? Okay, let's go with Howard.

ARNOLD: Arnold, new Board member.

I need to learn more about the fuel handling facility. How dependent are you on the ability of the fuel assemblies themselves to be handled without losing physical integrity?

CRAUN: Well, a fuel handling facility is designed, there's different cladding conditions. The license application addresses three. We have different ways in which we can receive failed or damaged fuel from the utility. If it's not known to be failed, then in fact we would expect to handle that directly, to lift that assembly up. We can receive failed assemblies, canisterized. One canister has a set of screens at the bottom to make sure that fuel itself doesn't fall out of the assembly or out of that canister. And, then, some of the individual fuel assemblies are canisterized, seal welded with an inert gas on top of that.

ARNOLD: Depending on that characterization to have been correct--as to the facility?

CRAUN: Yes, sir. We are relying on the utility records to let us know what material is in there. The DOE, on the other hand, we're relying on a very robust canister for the spent nuclear fuel, DOE spent nuclear fuel, and a less robust canister on the high-level waste.

GARRICK: So far, I have Duquette, Mosleh, Hornberger, Latanision and Abkowitz. Duquette?

DUQUETTE: Duquette, Board.

As you probably are aware, a perennial issue with this Board is the temperature of the canisters in the repository.

CRAUN: Yes, sir.

DUQUETTE: One way to accomplish a lower temperature, of course, is a longer aging period on the surface. If you go with the longer aging period on the surface, does that change your design appreciably, and how?

CRAUN: Well, currently, all surface facilities are designed with a 50 year life. Subsurface is 100 year life. So, if we went beyond the 50 year life period, we'd have to redo that preclosure safety analysis associated with that.

DUQUETTE: Duquette, Board.

But, wouldn't that also mean that you would have to increase the size of your surface storage facility for aging?

CRAUN: It's a topic we've spent a lot of time reviewing. Currently, we've done calculations that are very dependent on the sequence from which we, or the sequence that the utilities send us material, drives the size of the aging capacity appreciably. If, in fact, we would use it to, shall we say, in general, cool down the fuel before it goes subsurface, that would necessitate a larger capacity aging system. Again, in this license application--or excuse me--in our license application, we are asking for 21,000 metric tons, with a contingency of 40,000 metric tons.

As part of retrieval, we have in the license application areas which we would use for bringing the material from the subsurface to the surface if in fact we have to enter into a retrieval situation for whatever reason. So, there are other areas that would be available to us for aging. It's different than retrieval, but there is additional capacity in those areas.

GARRICK: Okay, I have Mosleh, Hornberger, Latanision, Abkowitz and Parizek.

MOSLEH: Mosleh, Board.

To what extent are these scenarios dominated by human error as opposed to system failure or equipment failure?

CRAUN: Actually, the NRC, over the last week, was asking us some of the same questions. The human error are included into the reliability terms for our hardware. So, the balance of how much is hardware failure versus human error, I don't know that I can answer here in an impromptu fashion. We are looking at trying to expand that clarity in our license application now, what we're writing, as to how much is attributed to the human factor portion of it, and how much is associated with hardware.

We've established, based on operational data from the commercial nuclear industry, for example, on crane reliability, all of the failures that have taken place, either being a drop of a fuel assembly and/or the partial extraction of that fuel assembly, and then driving the crane over and actually distorting the fuel assembly. We've looked at all of the different failures on the commercial nuclear side now, used those failures in looking at the number of lifts that they've made in our assessment of reliability. So, we're trying to combine both mechanical failure and human error also.

MOSLEH: Mosleh, Board.

So, the impact or the probability of human error is imbedded, included in the reliability of the equipment as opposed to a separate model of the process from the human perspective?

CRAUN: Currently, that's the case. Eventually, I would expect we would have to do, for example, as our design matures, we would have to do a failure modes analysis on the crane, or on the trolley, where, in fact, we would be able to separate that human component portion out and look just at the mechanical reliability. And, that would be closer to when we get into the detailed design for these facilities and equipment.

GARRICK: George?

HORNBERGER: Hornberger, Board.

If, in fact, DOE did at some time in the future decide that they needed to manage the system to keep temperatures lower, as David questioned, have you done the analysis, or is it a matter of simply extending the storage, or is there additional handling? And, if there is additional handling, is there, then, added risk that would accrue to real people?

CRAUN: Currently, the handling, as I breezed through quickly earlier, was we're assuming we have to handle it four times. So, every fuel assembly currently is handled four times. That will get it from the national conveyance into a staging rack, out onto the aging pad, back into a staging rack, then back into a waste package. So, we've already accommodated in our numbers on our preclosure safety analysis, the handling of four, every element four times.

GARRICK: Ron?

LATANISION: Latanision, Board.

Two questions. The first one I think is very straightforward, and you may have answered it. But, what is the timing from arrival of the cask to placement in the drift? What is expected time of all those steps?

CRAUN: I don't know that I really have a straightforward answer for you. It's a good question, but it has to do with how we buffer the material in the buffer areas to try to campaign in each of the facilities. I could give you information that it takes 44 hours to close a waste package. It would take 20-some hours to off load, approximately 20-some to off load a rail cask. But what you're saying is from the point in time of receipt, to its underground, it really varies as to how we would operate the facilities, and the amount of buffering that we would have to do. I just don't have a straightforward answer.

LATANISION: Ballpark?

CRAUN: Threeish weekishes.

LATANISION: Pardon?

CRAUN: Three weeks, two to three weeks. That would be straight through.

LATANISION: Latanision, Board.

You left this slide up here, and it provoked some questions.

CRAUN: Oh, I didn't mean to.

LATANISION: We've had a lot of discussion about drip shields over the last couple years, and I don't recall seeing this design before. Alloy 22 base plates, Grade 24 structural supports, Grade 7 canopy, I guess. Is this something new, or have I missed it?

CRAUN: I've been predominantly focusing on preclosure. I know this is installed at the end of the preclosure. I believe this is representative of the current design. I have not been looking at the drip shield.

LATANISION: Latanision, Board.

Has the design changed since May?

CRAUN: I think there's been some subtle changes. I believe the--now, if anybody in the audience, if I say something wrong, please stop me quickly. I believe the angles associated with these downcoming portions, we've kind of broadened that base, I believe, a few degrees. That's a change that I'm aware of. I'm not aware of any other major material changes to the drip shield. Again, I've been focusing predominantly on the preclosure.

LATANISION: Okay. I don't want to take a lot of time with this right now. But, I don't recall these materials of construction, and it provokes questions about the compatibility of Alloy 22 and Grade 24 in contact. It provokes questions about the entry of hydrogen into these materials. We know the titanium alloys are susceptible to embrittlement in the presence of hydrogen. And, so, I'm just sort of mystified that at this point, unless I've really totally missed it, there's a design I haven't seen before, and I don't know anything about the compatibility issues.

CRAUN: guess what I would propose is that in order to get you the best answer, would be to bring this back up as either a follow up issue that we can communicate on to get into the detail of the material selection capability, which I'm really not current on.

LATANISION: Thank you.

GARRICK: Mark?

ABKOWITZ: Abkowitz, Board.

I wanted to return to the aging pad aspect of the facility design, and, you know, recognizing that 40,000 metric tons of aging, or you could call it interim storage capacity is equivalent to more than half of what you'd actually want to put into the mountain, so, we're talking about a substantial amount of waste that could potentially be sitting on the surface for a considerable length of time. And, I was curious as to whether or not those risks have been incorporated into the categories that you described, and also, in particular, whether there have been any security studies that have been conducted, given that you have large amounts of this waste congregated in one area in a location that would be more accessible than if it were underground?

CRAUN: Let me go back to, I believe, Slide 5, please. Let me address again, if I missed that, this is contingency aging, so at this point in time, our license application would be for 21,000, four elements of five and one element of one. In the license application itself, it has an "as necessary" portion of it. So, for example, even though this is color coded as red to be brought on line with the canister handling, and the transportation cask, we will develop that as necessary for both the red and the green, so that as we get into operations, the license would address that amount of aging, but not be required for us to have it in operation. So, that would be one aspect of the question that you asked.

Again, the contingency study is based on our environmental impact statement. It analyzed the surface operations for 40,000 metric tons. The security analysis, the threats that we're considering for the surface facilities are underway now. So, we are looking at that from a security perspective. I didn't point this out, but that facility there is our central control center facility. It actually controls subsurface emplacement, and in that facility would be all of our security systems.

I can address one other aspect of, I believe, what your question is, and that is associated with dose exposure. For example, here, we have 1,000 metric tons. So, that as I have this facility, the fuel handling facility, or the canister handling facility in operations, I will, from my preclosure safety analysis, be looking at the dose consequence for now the on-site public, that would be a construction worker in this area, from the aging facility and from the canister handling and/or from the fuel handling. So, in many aspects, we look at the impact of the aging facilities from a dose consequences and an operations consequences. I hope I answered your question.

GARRICK: Okay.

PARIZEK: Parizek, consultant.

On the drip shield, when does that go in? Is that at the very end when you finally decide you're going to close up the whole facility, or when an emplacement drift is full of its waste packages, then you put the drip shield in?

CRAUN: At the closure, would be after we receive an authorization from the NRC to actually close the repository. At that point in time, we would start the closure process, which would be the addition of the drip shield and/or the removal, as discussed I think earlier with John, the removal of some of the circumferential drifts and/or access mains, some of that material would have to be removed as a result of potential impact on the performance of the repository. So, that would be at the end of its operational life.

PARIZEK: And, as far as the temporary closure, say when a drift is full, what do you do, you close a door at the curvature end of it, or what's the temporary measure there versus the final measure?

CRAUN: There is a door there. There's really no closure operation once an emplacement drift is loaded. Whenever the waste package transporter is not inside there, then in fact say the drift is loaded, the waste package transporter is out of there, the gantry would be removed from the emplacement drift, and then you would have the door close, but you would have a set of louver systems controlling the subsurface ventilation during the operational lifetime of the subsurface.

PARIZEK: One other point. When the waste arrives and you happen to have a leaker for reasons of damage in shipment or for whatever other reason, I wasn't clear what you do with a leaker when one arrives. You inspect to see if you have a leaker, but if you do have one, what do you do?

CRAUN: You mean--

PARIZEK: Shipping cask.

CRAUN: Well, those would be processed. I mean, we would process pinhole, hairline fracture, those that the utility is aware of. If we receive one where, in fact, we do a gas sample in the fuel handling facility and/or in the dry transfer facility where the bare assemblies would be handled, then in fact we would go ahead and process it. We'd take it to the fuel transfer area, we would transfer that over into a waste package, or into a site specific aging cast. We would inert it, and either age it, if it's a site specific aging cask, or we would take it to the subsurface.

The operational details of exactly how we would do it, we would have more of a propensity or tendency to just go ahead and load it directly into a waste package to make sure that we don't have to handle it again, those have to be thought through as we go forward with the detailed design and establishment of the operational characteristics and detail.

PARIZEK: Thank you.

GARRICK: Petrosky?

PETROSKY: Petrosky, Board.

You've shown us several design, schematics for, for example, the transportation casks and the fuel handling facility, canister handling facility, and I assume that these are either new designs, or they have new features for this particular operation, this project. Is that correct?

CRAUN: I'm not sure why--I didn't mean to infer that they're new designs as such. They're the current design that's being captured in the license application, like the casks.

PETROSKY: Yeah, the casks, but then these facilities would be specific to Yucca Mountain?

CRAUN: Yes, sir, that's correct.

PETROSKY: That is what I meant.

CRAUN: The equipment we would use in the facilities, for example, the fuel handling, the actual mechanism that picks the assembly up and places it into a waste package, that technology we would use to the extent possible, we will use existing technology.

PETROSKY: And, in looking for failures in the operation, you've looked at historic cases?

CRAUN: Yes.

PETROSKY: What the record has shown. Have you imagined that there would be any new cases, new failure modes that could possibly occur in this new situation?

CRAUN: Actually, that's a very good question. The repository being licensed under Part 63 versus Part 50 gives us some interesting kind of combinations that we're looking at as far as is it part of your radiation protection control program to monitor door interlocks, or is it part of your important to safety design. So, there's some interesting questions that being under Part 63 that are requiring us to have a detailed discussion currently with the NRC. But, no new type of failure modes.

ARTHUR: I can just help you there, Rick, on one area. Arthur, DOE.

As Rick talked in the beginning, I mean, we're--a phased approach to construction and operations of this repository, and, so, I don't want you to go away here today thinking these are all first of a kind, because a lot of them are not. If you look at the one that we call the fuel handling facility, the first ones that come on line, it's today's version, modified to today's safety standard what was Test Area North up in Idaho years ago. I'd started up there, we had a lot of different fuel, a lot of different type areas. So, we've taken that design and brought it up to what's required in today's requirements under NRC licensing.

Canister handling facility operations, as Rick talked, is, you know, canisterized, not bare fuel, so a lot lesser risk, but we still manage it very importantly. The bigger facility, which is a very big one, we didn't mention this today, but dry transfer facility, it will handle about everything there. But, it's almost, a lot of the design support we're having there, along with Bechtel SAIC's Cogema, so if you went into La Hague in France at some of the operations, some of the same type of handling lines, and similar type of experience, so we're trying to bring other areas that are actually working today, so it's not all developed here.

And, so, I just wanted to share with you, we are trying to bring in other operational history in that, at least for the surface.

PETROSKY: Well, thank you for that clarification.

Let me just continue a little further then. We've seen numerous things that have been written about the Challenger and the Columbia shuttle disasters. Those are attributed to failure modes, if you will, that there were precursors to, many precursors that were not absolute failures, but were glitches, if you will, that didn't lead to any serious safety matter. And, then, those things became incorporated into the culture of NASA. Are those kinds of concerns being looked at?

ARTHUR: Arthur, DOE.

Very much so. I know Mark and I have had many discussions in previous meetings, and I'd invite you to our offices sometime to go a little bit more in detail to some of the numbers I showed you this morning. We benchmark a lot with industry. We're well aware, and that's when I use that term, it's not just the license, it's the operating culture conducive of a licensee. I could talk to you for hours on what we are doing on safety conscious work environment, corrective action program, benchmarking with other utilities.

We've talked to others that have had successes and failures in the past, and we're trying to bring it together here, a very complex project. I mean, first of all, we're talking of something that would be constructed in December of '07, at the earliest right now. So, we're still transitioning through science, and continuing science, but going into engineering and licensing, and we have 2,500 very dedicated people here, a lot of them different backgrounds. To get all that in the same fashion operating as one licensee is a big challenge, but we take that equally important. And, I'd welcome further discussions, because we look at it every day equal to the license itself.

GARRICK: Nelson?

NELSON: Nelson, Board.

Two quick questions. I'm a little bit confused by the use of your word "aging," for the aging pad, because it doesn't seem that the main purpose is aging for reduction and heat. It's more like a staging place.

CRAUN: Actually, the purpose is for aging, from a thermal operations perspective on the limits for the waste package of 11.8 kilowatts per waste package, it is our intent to use the aging pad for purposes of aging that fuel. We have recently added the capability of being able to use it for a way to manage the operations to some extent on the surface facilities. But, its primary purpose is for aging of the fuel.

NELSON: Okay. Nelson, Board consultant.

Is the aim there to balance the heat load in each package item placement, and if so, how closely do you think you're going to try to limit the variation from package to package?

CRAUN: There's a couple of design criteria that we have to meet. The first is a not to exceed, and that's the 11.8. So, I simply would, from an operational perspective, which would be enforced by our licensing technical specifications that we would get from the NRC, I will have a limit of 11.8 on a waste package. So, I will not be allowed to load a waste package greater than that.

The other that you refer to is associated with our subsurface. There's a thermal objective there of 1.45 kilowatts per meter. And, so, we would have to manage the emplacement of the waste packages in a configuration that met that overall emplacement limit. So, I will again have tech specs term of art in an NRC license environment which would prevent me from operating outside those configurations. So, subsurface is 1.45 kilowatts per meter. And, I believe that is applied over a seven or twelve waste package set of configurations. And, then, the other is the 11.8.

NELSON: Nelson, Board.

So, this gets back to an impact on good thermal modeling underground in all rock units to be able to know that the 1.45 is right, because the aim is to obtain some uniformity in the thermal field; right?

CRAUN: It's easy from my standpoint. The 1.45 is from postclosure, brought into preclosure as to how I'm allowed to load and operate that. So, I think from the basis of the 1.45 kilowatts per meter, I would have to turn to subsurface postclosure people. That's coming out of TSPA.

NELSON: Nelson, Board.

That's an interesting number to think about. Just one last thing on the drip shield. I'm curious, and you probably aren't the right person to address this, but the drip shield, why are there ribs inside in the crown, and then exterior ribs on the outside, down the side? I'm just curious, because it indicates someone thinking about where they should be.

CRAUN: During a seismic event, it's associated with the overlapping of the drip shields, I believe is the answer.

NELSON: That explains the roof, but not necessarily--I mean, I'm just curious, because you have the external ribs, if they're welded or if there's welds out there, the welds are susceptible--

CRAUN: I think as I offered earlier, as we get to the point where if you would like more detailed information on the drip shield, we can get those people here that are associated with the drip shield.

GARRICK: We're bumping up against the next speaker's time, but I want to take two more questions, one from Busch and one from Duquette.

BUSCH: Busch, new on Board.

I need to have a little better feeling for how these complex systems operate. You said four times you have to handle a given assembly, whether it be a cask or whatever. And, you described in detail some very interesting motions, or moves that you have to make inside. For example, welding.

Can you give us some feeling for the extent to which personnel are involved in any of these activities? To what extent, is this fully robotic? You know, you talk about the possibility of exposure here and there, if you have an accident and you get a clean-up system. You showed us a transporter out in the field, or going down the road with a man driving it standing in back of such a cask. So, I begin to wonder to what extent these are automated.

CRAUN: Let me try to address that from the standpoint of subsurface. We would have a manned transporter bringing the waste package transporter subsurface, down the north ramp, to an emplacement drift. Once the waste package transporter was at the emplacement drift and was backing into the emplacement drift--

BUSCH: I'm really more concerned with the--

CRAUN: I'll get to the surface. Then the emplacement of that via the gantry would all be done from the central control center. On the surface facilities, why don't we go forward about two slides again, three or four. There. The operations that will take place in this vestibule would be typically manual operations. So, the upending of the cask, putting that cask onto a trolley to bring into here, that would be a local environment. Sampling of the cask, gas sampling, would be done locally here, done by, the attachments would be attached by personnel, and then the gas samples would be taken off in this facility and analyzed.

The operations of transferring the fuel would be done by operators. This is the first level. They would be on the second level, with viewing windows right interior to this wall up above. So, they would be having remote control of the fuel transfer cell equipment.

The waste package welding typically is a complete automated system. So, once positioned correctly, then it would be an automated position, or process. There is actually a post-welding waste package decon and/or contamination survey. There's some manipulator arms that you see here that would be taking surveys of the surface of the waste package. Operations, personnel would be on the other side of this shield wall.

The down ending operations, again, the operators on the other side of this shield wall would be controlling that crane that would be down ending the waste package onto the pallet, trunnion removal. So, quite a bit of the operations evolution is done, anterior to the building, is done locally, supervised. It's also supervised from the central control facility. We have an interface technology that we're tying all of the video observations in these rooms to a series of control stations in the central control facility. They will not be able to operate the cranes. They do have the ability to terminate operations from that location, so that if there's some unusual operations evolution that's taking place that they don't feel comfortable with, they can't redirect it, but they can stop it.

That is being brought in. Again, the only truly, and the other remote system, which I already described, was a subsurface gantry, waste package pallet emplacement.

BUSCH: So, there are very few locations in these fuel handling facilities where personnel don't pass through them?

CRAUN: Well, there would be, in the primary zone here above, these have docking collars on each of these that dock into a lowerable floor. In that fuel transfer cell, there would be very, very little personnel access at any time. There is a maintenance area, third floor up and over, to maintain that equipment. So, there may be some limited personnel access here.

This Zone 2, these are shield doors on the waste package welding area. These are also shield doors shielding each of these casks, canisters and/or waste package. We do have personnel access for a specific evolution in this building. For example, this facility can not only transfer fuel assemblies, it can also transfer canisters. The canister transfer process on your, I believe, the following image in your handout, there's a little yellow zone right here. That would be where the canister handling transfers would take place.

The lifting attachment for the Naval canisters is an attachment that has to be installed manually. So, we would have personnel in this Zone 2 during that manual installation. Then, as the canister is being transferred, this would become an extremely high radiation zone, and those personnel would no longer be in there.

GARRICK: One final brief question from Dr. Duquette.

DUQUETTE: Duquette, Board. A very quick one. This follows up on Mark Abkowitz's question.

You responded to the aging facility with almost half of your potential load at 22,000 tons, or even as many as 40,000 tons, which would be more than half, as being secure for the personnel who work there. It seems to me that that's going to be a major security issue for any kind of, I hate to use the word these days, but terrorist activity, or any other kind of external activity. Do you see anything unusual about having to secure the aging areas?

CRAUN: Well, the design basis threats, the facilities are going through that analysis now, so that we are addressing design basis threats from the NRC that are required for us to address in our license application, which would be a concurrent, but separate submittal, typically restricted in access to that, that would address both the surface facilities, the aging, all operational areas will be addressed in those design basis threats. We are looking at it from an NRC design basis threat perspective, and also from a DOE design basis threat perspective. The DOE is a little bit more aggressive in its threat. I should probably stop at that point. There have been several classified meetings as to what those threats are, but, again, in a classified format, we could get into that.

GARRICK: Okay, very interesting discussion. I wish you could go on, but we are invading on other people's territory now. Thank you. John Ake?

AKE: Well, thank you. Good morning. Thanks for the opportunity to address the Board again. My name is John Ake and I'm working with the DOE on some seismic issues at Yucca Mountain.

I want to take this opportunity to bring the Board back up to speed on what's been going on with respect to development of more realistic low probability ground motions. But, I'd like to start out by going through a bit of a summary of the studies to date, and I'd like to, just right off the bat, apologize to the carry-over members of the Board, and some of the staff members, because much of what I'm going to talk about in the first two-thirds of my talk, you've already seen. But, we think it's important to try and provide some more background and context for the new Board members. So, those are the two things I'm going to focus on today.

Let's go onto the first couple slides. As you're all aware, the regulatory framework for Yucca Mountain requires a risk based performance evaluation. And, with that in mind, it's necessary to evaluate the seismic hazards at the site within a probabilistic context. And, the PSHA that we use here for that at the Yucca Mountain site was conducted using a very specific formalism, as outlined in a report by the SSHAC Committee here. And, that's an expert elicitation methodology with rather structured formalism to the meetings and directions and guidance to the experts on the panel.

That particular methodology has been reviewed by the National Academy and previously accepted by the NRC in nuclear facility licensing.

I'm going to talk about a few of these things here. We claim that that includes epistemic uncertainty as well as aleatory variability in seismic sources and ground motions.

Now, seismic hazard evaluations of all types can be basically broken down into two component parts. The first is seismic source characterization. That defines the location of previous occurrences of earthquakes in the region, tells us something about how big those earthquakes have been, or how big they might be in the future, and how often they occur. That's really the critical element for PSHA.

And, given the site characterization, once that's completed, we have to then associate, of course we don't do design with just magnitudes and distances, we need to translate that into some ground motions at our site, and that's the second stage in this process is the ground motion evaluation.

Now, the PSHA for Yucca Mountain consists of the source characterization expert teams, consisted of six teams of three members each, different expertise in each of those different teams. And in our ground motion evaluation, we had seven experts on that broader team there, doing their individual assessments.

The output of the PSHA is, of course, the hazard curves for various ground motion measures, and unique to Yucca Mountain, for fault displacement at specific locations, both for preclosure and postclosure analysis.

A couple of other things on the left slide here we talk about in some detail. We state here that the aleatory variability in the ground motion attenuation, in other words, our ground motion models, is modelled as an unbounded lognormal distribution. And, I'm going to try and explain that to you in a couple moments over another slide or two, also, an important issue that comes back, sort of feeds into our discussion of bounding the peak ground velocity.

At the time of the conduct of this study, which was in the mid to late--or early to late 1990's, the final report was published in 1998, that was prior to the issuance of 10

CFR 63, and based on previous experience in the nuclear power plants, the anticipated range of annual frequencies of interest was 10^{-4} to about 10^{-6}. And, because we were interested in mean dose consequences at the end, we sampled the mean seismic hazard curve in the TSPA analysis.

And, I'm going to go over this a number of times. We have put a strong focus on incorporation of uncertainty in these analyses.

Now, the various data sets that go into doing the seismic hazard analyses are outlined in the flow chart on the left. For seismic source characterization, we're interested, we've appealed to seismicity data in the area, broad regional geological mapping, as well as more site specific mapping, some early geodetic measurements, as well, and then more focused evaluation of paleoseismic trenching investigations for faults of particular interest to the hazard evaluation.

Those components all feed what we refer to as the seismic source models and weights here. The various teams were tasked with looking not only at models they themselves might have developed, that they are proponents of, but also other people's models as well, in trying to assign subjective degree of belief weights to those other models, and incorporate those into their overall model of the seismic source behavior in the Yucca Mountain area. The output of that then are the location of future earthquakes, how often they happen, what is the magnitude associated with those.

In addition to the seismic source models here, also in a way, and these same data sets feed our fault displacement models and weights, and that's something that's sort of new and different that people haven't done much with in the past, and it was certainly a challenging exercise to come up with fault displacement probabilities for various locations in the repository and surface facilities.

Once the seismic source characterization is done, the ground motion modelers, or attenuation experts, come in and the data sets they use are existing empirical ground motion recordings, as well as the results of theoretical calculations of ground motions. And, they go through the same process where they evaluate different models and apply weights to those models on an individual basis.

These two pieces are then combined, and the output really then are the hazard curves for ground motion probabilities.

As I'll explain a little bit later, there's another step here, and that is to actually take those sort of generic ground motion probabilities, and translate those into site specific ground motions, and we do that through the use of our seismic site response model. And, the input data to those are the site specific solid and rock properties.

The box here says preclosure seismic design and safety analysis, but exactly the same process goes into development of the ground motions for postclosure safety assessment.

As part of the data gathering activity here, a large inventory of faults were evaluated within 100 kilometer radius of the Yucca Mountain site there shown by the red star, and what's shown here are the potentially active, potentially quaternary active faults in that 100 kilometer region. And, there's, as you can see, a fair number of them. Those were all evaluated by the source characterization teams in their modeling, in their development of their models.

We, of course, because ground motions tend to die off with one over distance, we're of course most interested in those faults in the immediate vicinity of the proposed repository here. This is the Yucca Mountain structural block itself. We spent probably the greatest amount of time and effort on those faults. But, we did consider other faults that were more distant from the site, and of course the degree of enthusiasm that we went after trying to characterize those depended upon how close they were and, obviously, what their activity rate is. The more active more distant faults got quite a bit of attention.

Next. So, in addition to that sort of regional synthesis of faults in the area, we paid, as I said, particular care in dealing with the more local faults here. This shows the Yucca Mountain structural block here, the proposed repository in pink, and all the faults that are shown in bold brown here are ones that have either documented quaternary or suspected quaternary movements. So, those are the ones that we are interested in from a seismic hazard standpoint.

And, a great number of those actually, I think there are a grand total of about 40 trenching investigations were conducted as part of this evaluation, most of them in the near field area here. The trench locations are shown in red. The data that comes back from the trenching investigations, obviously we are able to--the trenches are typically done in alluvial materials. We can date the various alluvial packages, and this gives us some information about when the ages of the last fault and events occurred. That tells us a great deal. That's the primary data set we used to establish the relative frequency of events, or the absolute frequency of events on particular faults.

In addition to that, much more detailed structural geological mapping and shallow seismic reflection data were acquired that allowed us to come up with much more detailed geometry of the subsurface configuration of some of the faults here.

A couple faults I'd like to point out, one is the

Solitario Canyon fault, which forms the western boundary of Yucca Mountain here, and it dips to the west, it's right there, and also the Paintbrush Canyon Stagecoach Road fault system off to the east. There's about four kilometers to the east of the middle of the repository, and it also dips to the west.

The variation in dip of some of these local nearby faults caused some of the source characterization teams to come up with some rather elaborate models of, both a long strike geometry and change in dip, caused the source characterization teams to come up with some rather elaborate models of multi-segment rupture and coalescing faults at depths. Some of the logic trees were for fault rupture modeling, they were pretty detailed.

Let's go onto the next one, John. In addition to the geological investigations, we also developed a catalog of seismicity in the Yucca Mountain area, in the upper right here shows all earthquakes, regardless of magnitude, within a 300 kilometer radius of Yucca Mountain. The majority of these events are--Yucca Mountain is right there--the majority of these events are, of course, fairly small. The catalog was really augmented by the fact that DOE supported the operations of the Southern Great Basin and Seismic Network for more than 20 years. This shows an early version of the network here, where it was a bit more regional in scope.

Yucca Mountain right there. Older analog stations at the time the network was originally installed, it's evolved to be a mostly digital network now, state of the art digital equipment here, mostly focused on the Yucca Mountain area.

Originally, the network was operated by the Geological Survey, U.S. Geological Survey, and now currently by the University of Nevada Reno, and they've really done a very good job in operating this network for us.

You can see when we filter this set of data here by earthquakes of magnitude 6 and larger, you can see that there are a few events of magnitude 6 and larger, but the majority of these events are smaller. I should point out, let me see if I can get this to hold still, the large blot of data right here are earthquakes that are in the northern part of the Nevada Test Site, and they are associated with nuclear explosions previously.

One of the reasons we're interested in developing the seismicity catalog, in addition to modeling the hazard from map surface faults, all six of the expert teams also incorporated what are called aerial background source zones in their hazard models. Those are a way that we can incorporate hazard from faults that at this point in time, we don't know they exist, and we have to find some way to incorporate the hazard posed by that, earthquakes of that type. That would be similar to the 1992 Little Skull

Mountain earthquake which occurred right in here, magnitude 5.6, didn't rupture the surface, nobody was aware that there was a source at that point.

So, the seismicity data allows us to come up with a current earthquake occurrence or recurrence relationship for the aerial source zones.

Now, the task to our ground motion experts was the following: develop predictive ground motion equations for various magnitude and distance scenarios, large number of magnitude and distance scenarios, for a specific situation, which is this hypothetical reference rock outcrop here. The reference rock outcrop, its geometric location would be at the center of the repository, elevation equal to the proposed waste emplacement level here.

Physical characteristics of the tuff would be those similar to the tuff units at the waste emplacement level in terms of their density, attenuation characteristics, and seismic wave velocities.

This is the easiest process for the ground motion experts to deal with. And, given the amount of different magnitude and distance bins we asked them to come up with predicted relationships for, this was really the only workable way to do this.

Now, on the right, we show a schematic distribution from one of the expert's models for this particular situation, magnitude 6 1/2 at a distance of one kilometer, for a normal faulting earthquake, which is what we, you know, normal gravity type slip on these faults, is what we infer that most of the faults in the near field are responding to. And, this is, of course, a lognormal distribution. And, a moment ago when I said we modeled the hazard from the faults, or from all the seismic sources as unbounded lognormal distributions, this is what I was referring to, which is shown in red here. And, you can see we have non-zero contributions out to, they're a very small probability, but non-zero contributions out to fairly high ground motions here. The ground motion measure we're interested in here is peak ground velocity in centimeters per second.

You can see the most likely, maximum likelihood kind of estimate here would be at about I think 25 or so centimeters a second, and the median of this distribution as drawn is shown by the blue arrows, about 38 centimeters a second, more or less.

Now, the measure of course of the variability in this function, the aleatory or random variability in this process is the standard deviation, sigma here, which is shown for this case by the magenta arrow. And, of course, the observational data base shows that for a given magnitude earthquake at a given distance, there is a broad range of observed ground motion values, which is what that function shows us.

We also asked our experts, after looking at all the various models, well, give me an estimate of the uncertainty in your median estimate. And, we also asked them as well to give us an estimate of the uncertainty in the variability, what's the uncertainty in the sigma value here, and that's what's shown by these arrows here.

So, the uncertainty in this, when you hear people talk about the epistemic uncertainty in the aleatory variability, when they link all of those terms up, that's what they're talking about, is how much uncertainty there is in that.

Let's go onto the next one, John. So, when we combine then the efforts of the source characterization teams with the predictive ground motion equations of the ground motion experts, we get results similar to this. These are intermediate results here, and they're for two particular ground motion measures, peak ground acceleration and peak ground velocity, for two different teams, Team ASM and Team DFS.

And, there's some things you can see from these. These are then aggregated over, for each team, over all six ground motion experts, and those results are then combined.

A couple things I'd like to point out here very quickly. At higher annual probabilities here, and smaller ground motion values, are aerial or background source zones tend to control the hazard, and as you move out to annual probabilities consistent with the annual probability of getting an event, any event, on the local sources, although I should point out that the local sources all have relatively low slip rates. They give up earthquakes on a very infrequent basis. But, as you move down here to lower probabilities where those sources begin to contribute significantly, they control the hazard at the higher ground motion values.

Okay, next, John. So, once we take plots like those and aggregate it over then all of the different source characterization teams, you end up with the final hazard curves. An example is shown on the right here. And, this is for peak ground velocity is the ground motion measure of interest here. And, this is for our reference rock, our hypothetical reference rock outcrop. And, I may slip up here. We're kind of dropping the term Point A and Point B, but we refer to that also as the Point A, that hypothetical reference rock outcrop.

I'd like to point out a couple things about this curve, which will stimulate the discussion that goes on in the second half of this talk. First, notice that just the mean value, which is shown here in green, notice the extremely large peak ground velocities that are calculated for small annual probabilities of exceedence here, were out beyond 10 meters per second in this range out here. Those were incredibly large ground motions. Our observational data base has never observed anything at all like that. So, we have some suspicions about those low probability results.

The second is notice the difference in behavior between the fractile values here for the 5th, 15th and median, or 50th percentile values here. They tend to be fairly linear and fall off fairly quickly here. The high fractile values here, and including the mean in this case, which is greater than the 90th percentile out here at 10^{-8} are tending to show a curvature that suggests for arbitrarily small probabilities, arbitrarily large ground motions are possible. We find that difficult to support from a physics standpoint, basic physics standpoint.

And, the other is notice the wide disparity in the probability density for a given ground motion value out here between say the 95th and 5th percentile here, visually construct a PDF, if you will, for the 5th and 95th out here at, say, 10 meters per second, and you can see that's incredibly broad range of probability, because the probability axis is in log scale.

Next, John. Another way to look at those results in a way that's actually pretty important is to look at the contribution by hazard level, broken down in terms of the magnitudes and distances that are contributing to the hazard. In other words, it's telling you something about which sources are contributing.

On the left, we show the hazard level at 10^{-4} annual probability for the ground motion measure PGV, and on the right, it's 10^{-6}, and high frequency measured peak ground acceleration on the right.

What you can see overall is that the magnitude range contributing to the hazard at each of these levels is peaked at around magnitude 6, or a little above that. It gets more pronounced at the lower probabilities. Contribution out here is actually coming from the more distant Furnace Creek and Death Valley Fault systems, which cease to contribute at low probabilities. We just exercise that as much as you can get a contribution from.

So, you can see that magnitude 6 plus earthquakes, 6 to 6 1/2, at distances less than 10 kilometers, and it just becomes more pronounced for the lower probability levels here.

The other thing to point out is this factor we refer to as epsilon can be thought of, it's very similar to the number of standard deviations above the median that are contributing to the hazard. And, you can see as we move out from 10^{-4} to 10^{-6} epsilon hence, by analogy, sigma or standard deviation is getting, the contribution is coming more and more from more extreme values in that distribution we showed a moment ago.

Next one. Now, that's the results that came out of the 1998 PSHA study. But, actually, that's for our hypothetical reference rock outcrop here. We don't actually need the ground motions at the hypothetical rock outcrop for anything. We actually need them for the waste emplacement level here, you know, which is not--it has the same properties as this, but it is not a surface outcropping level, which does affect the ground motion significantly. And, also, we need for preclosure design activities, we need the ground motions at the top of the soil column over here.

So, we have to take into those situations, two separate situations into account, and we have to also incorporate the deaggregation results, those results I just showed you a moment ago. You can see we have at any given hazard level, given probability level, we had a range of magnitudes contributing to the hazard. The magnitude, the spectral content of the ground motions will change with magnitude, and it's necessary to take that into account when doing the site response analyses. And, that has been done. And, also, we spent a great deal of time and effort is trying to incorporate the uncertainty in the material properties here.

Next. So, to summarize the results that were obtained as of a couple of years ago, we saw very large ground motions for the low probability region of hazard curves. We, as I discussed a moment ago, did not find that to be intellectually very pleasing. And, in fact, if one tries to back calculate the seismic source parameters, it will be required at the seismic source to produce ground motions of those amplitudes. You find that those are physically unrealistic and unrealisible most likely, or at least very unrealistic based on knowledge we have at this time.

And, another thing we noticed in doing the site response studies is when we looked at the strains that would be produced by those very large ground motions, they seem to be inconsistent with the material properties we knew something about in the rocks.

February 2003, some of these results were presented to the NWTRB, and in their letter back to us, they indicated some of the same reservations that we had.

Next one. Based on what we felt, plus the response of the Board, we undertook a study to try and develop realistic bounds on the ground motions at Yucca Mountain. In particular, the ground motion parameter we focused on was peak ground velocity, because that's the ground motion parameter of merit for the development of the time histories, and for what we were also using for some of the seismic consequence calculations.

And, what we really, I guess the short story out of all this is that again, the calculated ground motion levels at low probabilities, we felt were probably physically unrealistic and may not be credible, and the regulatory requirement of 10 CFR 63 is that only credible inputs be used in TSPA. So, that was really one of the major motivations for this.

And, I'd like to sort of, probably the short cut out of all this is really Professor Parizek's comment of earlier this morning, which is the rocks really do matter. I mean, the rocks tell us something, the physical strength of the rocks and what observations we can make about the rocks in the tunnels tell us a great deal about what can and can't happen to these rocks, and what in fact has or has not happened in these rocks. And, that's really I think the short story here on these two slides.

Go ahead. So, this is really our fundamental physical constraint here, is that the ground motion amplitudes that one can propagate through any rock mass is limited by the strength of the materials through which they propagate.

And, in particular, for most ground motions of engineering interest, the largest amplitude is carried by the shear labor S-wave, and so the thing that we're most interested in is whether the shear strength of these materials. And, what we've tried to do is establish a shear strain limit that would be consistent with wide-spread failure and fracturing within these materials. And, since we do not see those types of fractures in the ESF or the cross drift, we think we can use that as a reasonable bound for the ground motions at the site.

And, in particular, we're interested in the lithophysal tuff units, the lithophysae, of course, being gas bubbles that formed when the tuff units were cooled. They are the weakest material that one would encounter there. And, so, since these materials we're asking them to operate at not necessarily seismographs, but more seismoscopes, they don't record a ground motion per se, but they are able to record a threshold of ground motion. Once a threshold is exceeded, that leaves an imprint in the rock, if you will, in terms of fracturing.

And, the criteria, the fracturing criteria we come up with needs to be consistent then with the observational limits of our geological mapping within the tunnels. And, once we have established that, we can then calculate the ground motions, in particular, peak ground velocity, that are consistent with those strains, and we can use that to inform our hazard curves for use in TSPA.

Next slide, John. The particular data that we appeal to for this analysis are mostly the large core tests, laboratory tests that were done, where these cores were loaded to failure in a big apparatus like this. The slide on the right shows a stress strain curve, the relationship of axial stress to axial strain, for one of these cores like this. We used the large scale cores, because we needed to get, these are one for diameter cores, we needed to get a sample that was big enough to include some of the lithophysae in the sample. Smaller samples, you can only really just get the matrix material. You can't capture the effect of the lithophysae on the overall mechanical behavior using just the small samples.

We used the results of these studies, the laboratory tests, rather, to calibrate our micromechanical models, mathematical models of behavior, which we are then able to use to extend the results of these studies to larger scale, big blocks of material that are more representative of the overall behavior of the repository itself.

The critical parameter we focused in on here is the peak strain up in this area here. This tends to manifest itself when we have lots and lots of failures going on in the sample. The time that you get to peak strain here, you're in really significant failure in this material. This shows the loading and unloading path here.

The particular value we're interested in is what we call the strain increment, which is the difference between the peak strain up here, and the in situ strain that would be on a sample like this at repository depth of about 250 meters down beneath the ground. And, that's actually somewhere in here, I believe, is the overburden stress.

Next, John. So, in addition to the laboratory testing, we've also done some modeling, defamation of the lithophysal units. What we show here on the right is the results of one of those types of studies with a particular code called the particle, PFC, particle flow code. This is work done by Atasca Corporation.

Here, the lithophysae are modelled as just randomly, nearly uniform size, random orientation of lithophysae in the sample. And, whenever we load these to a strain consistent with the peak strain values we showed in the last slide, pretty similar results out of all these, you get widespread systemic fracturing, and the linking up between the lithophysae. In all of the ones like this, you see this, and also when you extend this to trying to model the lithophysae based on the detailed panel maps like this with no realistic lithophysal geometries, you see exactly the same sorts of behavior in all the results.

The geologists feel that widespread fracturing of this type would be easily discernable within their existing mapping in the tunnel.

So, we primarily rely on the results of the core samples here, augmented by the modeling results, to come up with a distribution, a probability distribution, of threshold shear strain for the lithophysal units in Topopah Springs. And, we're particularly interested in the red triangles here, which have a height of diameter greater than 1.5. Those are the lock mechanics. People feel that those are the most representative for assessments of this type.

You can see that the range of shear strain associated with that widespread failure ranges from about .09 percent strain, up to a little less than .25 percent strain. The modeling results typically showed that at about .2 percent strain, widespread fracturing was occurring in the materials.

The result of that was the development of this probability distribution function shown on the right here, which is shear strain in percent strain that is the level at which we feel widespread fracturing easily observable in the tunnels would occur.

Okay, John. Now, once we've established that as our shear strain distribution, we have to translate that now into some ground motion measure. The way we've done that is basically to appeal back to the earlier site response studies that were done with the unbounded ground motions, because part of the output of those model runs is the variation with depth of shear strain and horizontal peak ground velocity.

So, since we'd already run those with 10^{-4}, 10^{-5}, 10^{-6}, and 10^{-7} probability motions, we had a full suite then of these variation with depth of these two quantities, and we could back out a distribution on peak ground velocity, on maximum peak ground velocity for this site, which is shown on the right here.

The thing we need to point out on the right here is this is these curves, or these two triangles here, are the curves that form the basis for that probability distribution for bounding, PGV. And, the reason there's eight of these is that's the result of the incorporation of the epistemic uncertainty in the various material properties.

In particular, they separated the two sets of distributions here based on the choice of upper mean tuff, lower mean tuff, in other words, that is an assessment of the degree of linearity or non-linearity one expects in those tuffs when they're strained. And, that ends up being really a first order of things. The various other factors here for P1 and P2 represent different base case models in the velocity profile. Those are definitely a second order effect with respect to the uncertainty, epistemic uncertainty and how linearly the tuffs will respond when strained.

So, the composite of these two, this multi-modal function here, is in fact our best representation of the distribution on bounding PGV at this site.

Also shown is the uniform distribution here between 150 and 500 centimeters per second. This is actually the distribution that is currently being used in TSPA. At the time that it was necessary to provide this bound, we were still working on this issue with regard to doing the site response evaluation. And, we developed this as a proxy, we had a pretty good idea where this was going to come out, but we identified this as a proxy, and this of course is conservative in the mean with respect to this multi-modal function here.

Okay, John. Now, the savvy observer is probably sitting there asking, or getting ready to ask the question, well, you have, or are now applying this as a bound to your hazard curve, which is true. And, this is now our bound to the hazard curves at Point B, which is the repository elevation. The unbounded PSHA results are shown here. And, the effect of incorporating the uniform bound I just showed a moment ago and read is here, and our multi-modal bound is shown here in blue.

The savvy observer is probably saying, well, the rocks are only 12.8 million years old, but you're applying this bound down to 10^{-8}, why is that okay? And, the answer is we think it's okay for the following logic. One of the things we've done, I alluded to earlier that we had looked at trying to back out source parameters for these very large motions, and said, boy, those source parameters don't look very realistic. One of the things we did to try and place this in a probability context is to try and do scenario event modeling of a magnitude 6.7 earthquake at one kilometer distance, which would be consistent with the sources that control the hazard at low probability at this site, although that's probably a little conservative on the magnitude. But, it's representative. And, we used our site response model in conjunction with the stochastic point source model to try and develop distributions on expected ground motions at repository elevation, and in particular, we were interested in sampling over the attenuation properties along the propagation path, site response properties. And, for the source term, we sampled the so-called stress drop or stress parameter, using a distribution that was based on work done for earthquakes in the Western U.S. to form that sample for stress drop.

And, we ran about 5,000 runs in the sample, and we got a sampling over that broad range of these parameters, and the results were a mean PGV of about 31 centimeters a second, which was not unlike what we saw in our distribution function earlier. And, we also ended up with a total variability here, which includes epistemic and aleatory of a sigma and lateral log units of 0.71.

Now, the ground motion values that are consistent with a threshold shear strain then of about .2 percent, come out to be now at about 3 1/2 to 3.6 standard deviations above this mean value. Now, that's actually something like two times 10^{-4} probability of exceedence for that ground motion value. But, that's of course a conditional probability, conditioned on the probability of the earthquake actually occurring.

So, when you combine that probability with approximately 10^{-5} more or less probability on the nearby fault sources, you end up with a probability that's less than the probability of exceedence for that .2 percent strain, less than 10^{-8}. And, for that rationale, we feel that application of this bound in an absolute sense within this range of probabilities is a reasonable and justifiable thing to do, and consistent with development of credible inputs for the TSPA.

And, I'm going to stop right there.

GARRICK: Very good. We have time for a few questions. Let me start by asking a very global question. Do you have a good feel for what kind of ground motion frequencies and magnitudes would really get you in trouble? In other words, have the TSPA people told you what the packages can stand?

AKE: I'm probably going to have to defer that to Bob for the afternoon.

GARRICK: Because what you'd like to see is some of this data for events above that threshold, and see what kind of problem we really have?

AKE: Well, the waste package response calculations were carried out for a broad range on input motions. And, I'm not sure I'm completely following the question, so we have an idea of what the response of the packages will be at 10^{-4} level, 10^{-5} level, 10^{-6} level, and 10^{-7} level. I'm not sure that answered your question.

GARRICK: Well, no, I'm really curious about what really matters. I'm really curious about we've got pretty robust systems here that we're talking about.

AKE: Well, you know, based on my evaluation of what I've seen so far for structural response, I would say that that is exactly a true statement. The system is very robust. It is not like a big multi-span bridge, or something. It's pretty robust with respect to ground motions.

GARRICK: Okay. We can take a couple of questions. Yes, Ali?

MOSLEH: Mosleh, Board.

In your methodology for combining aggregating values results across the different teams of experts, and in carrying along the lines of keeping or separating or combining epistemic and aleatory distributions, did your aggregation of across the expert take place in the form of like basically aggregating like in averaging mean value across the experts?

AKE: No. I'm not sure I can easily answer that question actually. Obviously, each of the teams' resource characterization, their logitry was of course very large, had many different branches on it. Each output node of that was then combined with the output node, or combined, rather, with each of the seven ground motion experts. So, what was calculated was a huge number of curves, which are then rank ordered, and means are calculated off of that.

MOSLEH: I was trying to understand to what extent you captured the expert to expert variability in your uncertainties. Did you collapse them?

AKE: The expert's were all weighted equally. I'm not sure that's exactly what you're asking. I'm sorry.

MOSLEH: And, then, the results somehow combined are aggregated?

AKE: Exactly. All of the, like I said, for Team ASM, let's say their tree was, the hazard from each branch of their tree was calculated for each of the different ground motion experts, and then that curve is stored as each of the different range of variables and each of the different source terms, and ground motion terms, are calculated. It's the end of thousands of curves, which are then rank ordered, and a mean is calculated from that. I'm not sure I can answer that easily without drawing pictures. Sorry. I apologize.

MOSLEH: One more question. On the selection of models, for instance, you mentioned the choice of a lognormal model. Was that also subject of expert assessment, or a given?

AKE: No, that was not a given. The experts could have chosen any functional form for that model they wanted. They were merely tasked with coming up with predictive relationships for a particular magnitude and distance, predict the ground motions from that. But, the observational data base of earthquakes worldwide were in those instances where we have a fair amount of data for a particular magnitude and distance interval, it is lognormally distributed. And, in fact, theoretical calculation show there's some good reason why it should be. And, in fact, the theoretical calculations reproduce that observed behavior of lognormal, lognormal positive scale.

GARRICK: Hornberger.

HORNBERGER: Hornberger, Board.

I have two questions. First of all, just to calibrate, can you give me some indication of, say, what measured horizontal peak ground velocity we have for the Basin and Range?

AKE: Not much. Therein lies one of the problems, is the real lack of good observation in the Basin and Range for especially normal faulting earthquakes. Based on worldwide observations in similar tectonic settings, you typically see a few tens of centimeters per second. That's in the near field. I mean, obviously, it gets pretty small when you get very far away.

HORNBERGER: Right. And, so, then my second question is if I look last figure here, your hazard curve, is it safe for me then to infer from this that your analysis of the stress strain relationship in the tuffs is consistent with an exceedence probability--well, that the 300 centimeter per second peak horizontal velocity could have occurred in the last--at least once in the last 10 million years?

AKE: Well, actually, no, we think that--well, yeah 300 centimeters a second is within the range of our distribution, yes.

HORNBERGER: No, again, if I look at this, if I'm reading it correctly, between one times 10^{-6} and one times 10^{-7}, so then I read over and I see, okay, a peak, horizontal peak ground velocity of 300 centimeters per second, so at one times 10^{-6}, that would happen, you know, on average ten times over the last 10 million years. Would the rocks have withstood 200 or 300 centimeters per second?

AKE: That's a very good question, and I--we feel that the assessment we've come up with is still probably somewhat conservative, because 300 centimeters a second passing through these rocks would probably, especially if it was exposed several times, would probably leave a signature in the rocks. And, right now, we have a 12.8 million year record that probably represents, based on the closest faults, perhaps a hundred, or a couple hundred characteristic mass and magnitude types events on those, and we do not see any evidence in the rocks that they have failed.

HORNBERGER: So, then, we have to make sure that we do ask Bob Andrews John Garrick's question as to what difference this makes.

GARRICK: Yes, Richard?

PARIZEK: Parizek, consultant.

Has this been looked at again from Jim Broom's approach of precarious rocks to say, well, okay, here we are with some calculations. We could go around the desert in places where he's tried to do that. How does that match? This is kind of a dependent line of observation.

AKE: Yes. The problem with the observations that Jim is making with the precarious rocks is they're really only in forms up here in this part of the hazard curve, really up in here. Because the rocks themselves, you can only document a few tens of thousands of years in place in those precarious conditions, although it's somewhat more possible to possibly push that back a little bit in geologic history.

As you probably are aware, Jim cites observations like that as really in his view being a systematic--leads him to systematically question whether the amount of aleatory variability that we're putting into those relationships, in other words the sigma value, may be too big. Jim feels like aleatory variability should be smaller, and those lognormal distributions ought to scrunch down some. And, I think that that's Jim's position on that.

PARIZEK: Thank you.

AKE: I should also point out that another observation that Jim has made recently are looking at this particular region out here is going back and looking at the tuffs exposed at the ground surface that were exposed to the largest ground motions from the underground nuclear explosions. And, most of those rocks around the rims of the cap rock are highly shattered, lots of material down, things are really busted up at the ground surface from those underground nuclear explosions in the very near field. And, those ground motions are similar to or smaller than the ones that are proposed in the low probability region here, and Jim would argue that that tells him that those ground motions have never been seen in the last million years, or so. Because those are something you can document as a longer geologic record there.

GARRICK: One final question. John Pye of the staff?

PYE: Okay, Pye, Board Staff.

I'd like to look at Slide 27. Okay, the horizontal axis is porosity. Could you clarify? Is that total porosity or lithophysal porosity?

AKE: I believe that is total--I do not absolutely know the answer to that question. So, I'm not going to answer. I'm sorry.

PYE: All right. Well, let's assume it's a total porosity, which means you've got about 13 percent matrix porosity and the rest of the porosity is made up by lithophysae. Well, in the process of extracting a 288 millimeter diameter core, cutting the specimen, you're essentially truncating what would be the PBF of the rock mass, lithophysae porosity. So, my question is how do you scale this specimen up to rock mass scale to get a representative sample of the implication of shear stress or shear strain and rock mass strength?

AKE: That speaks to the question that I alluded to earlier, which is as you get to smaller samples, you're really under representing perhaps the effect of the lithophysal porosity on the bulk behavior of the unit. And, that I believe was one of the primary motivations for trying to do the micromechanical modeling, the UDEC and PFC work, was to try and get around that problem a little bit.

PYE: Again, maybe a point of clarification. The distribution of lithophysae and the upper lith or the lower lith is entirely different to the distribution, just size distribution, than in the lower lith. So, again, when you report the data here, are you including both upper and lower lith data in the red triangles?

AKE: I'm not sure about that. The report that I was looking at for this only specifies it as being lithophysal unit, as "lithophysal rock." I could probably have an answer for that after lunch, though.

PYE: Okay. And, again, if you would run a regression through the red triangle data, what would be the general implication?

AKE: That the correlation coefficient is pretty bad.

PYE: But, beyond that, as far as the strain and porosity data, what is the general implication there?

AKE: If you eyeball regressed on that, it would suggest that shear strain goes up with porosity.

PYE: Okay, thanks.

AKE: I would defer that one to Mark Board to answer on that one, though.

PYE: Thank you.

GARRICK: Thank you. Unless there's a burning question that you just can't wait for an answer on, I think we will adjourn until 1:25. Thank you.

(Whereupon, the luncheon recess was taken.)

AFTERNOON SESSION

ABKOWITZ: If I could ask people to resume their seats, including Board members? Thank you.

Good afternoon. My name is Mark Abkowitz, and I'm a member of the Nuclear Waste Technical Review Board, and it's my pleasure to be chairing the afternoon session this afternoon on Total System Performance Assessment, or the acronym that we've all come to know and love as TSPA.

In the opening remarks that John Garrick made this morning, he described the presentations that will be made this afternoon, so I'll only add a few comments. I think this prepared statement about my adding only a few comments is in deference to the last time that I ran a meeting, which ended about an hour late. So, this is my last chance, so help me out, please.

As we all know, TSPA will be the primary tool by which the regulatory acceptance of the proposed Yucca Mountain repository will be judged, and the DOE is currently finishing the latest version of TSPA, appropriately named TSPA-LA, that is the TSPA specifically prepared for the upcoming license application to the NRC. And, its importance cannot be over emphasized, not only in terms of what it means to the license application process, but if you also recall earlier today, John Arthur's slide indicated that it was in the red zone, which is, again, indicative of both the importance and the timeliness of having that done well.

From now until the mid afternoon break, we'll be hearing from Bob Andrews from Bechtel SAIC, who will be providing the Board and the audience with an overview of TSPA, including its approach and its fundamental assumptions. I kind of think of this as a tutorial where we'll get an opportunity to have Bob kind of explain some of the underpinnings of the TSPA approach, but keeping it above 10,000 feet, so that we don't end up spending an entire evening, and probably into tomorrow learning about everything that there is to know about it.

Because of the nature of the time frame that DOE is operating under right now, Bob will not show any specific results, since the computation and review process is not complete. However, Bob will describe the basic elements and the methodology, and also inform us of some important changes and assumptions that have been made between previous TSPA's and the current version.

It's a fairly lengthy amount of material that Bob will be putting together, so he's actually going to divide his talk into two parts, and the Board will have a question and answer period in between.

Following Bob's presentation, we'll take a short break, and then we'll hear from Tim McCartin of the NRC, who will describe the criteria for review of the TSPA-LA, and will also provide us with risk insights from NRC's own limited performance assessment studies of Yucca Mountain.

Following that, we will hear about a different approach to TSPA than that described by the DOE or the NRC. Mick Apted, who is a contractor to the Electric Power Research Institute, will describe EPRI's approach and provide us with some results from their analyses. These results may differ from those of DOE or the NRC, and we look forward to hearing the reasons for why these differences may exist.

At the end of the day, I'll hand the microphone back to John Garrick, who will open the meeting for public comments. I want to remind you that if you want to make any comments, please sign up with either Linda Coultry or Alvina Hayes--I'd ask them to raise their hands, but they're not back there. But, they will be--who will be able to submit your comments on the sign-up. If for some reason you're not able to stay for that period, or don't wish to speak publicly, you can submit your comments in writing, and as those questions and comments come up, please give them also to Linda or Alvina, and if time permits, we'll raise those as submitted questions.

Just a reminder on the carry-over from this morning, please make every effort to have your cell phones and pagers switched to the silent mode. I'm reminded of a time when that was not done, and we had agreed that whoever's phone went off, they owed everyone else a drink after the meeting. This looks like it would be a pretty expensive proposition. So, please act accordingly.

I also, before turning it over to Bob, wanted to make a couple of personal comments to Dick and to Priscilla, thanking them, not only for their service to the Board, but also for them entering of the next generation of Board members that I was part of, and we hope we can continue the legacy that you helped bring us to at this point, and I wish you well as citizens.

I also wanted to give a special thanks to Dave Duquette, who was mentioned earlier, served as acting chair of the Board for nearly a year. I worked very closely with Dave during that period, and I know how much effort and care went into the work that he did. And, it's very much appreciated, and he was able to keep the Board operating at a level that was consistent with its mission, and we're here today able to do what we're doing because of that leadership.

I'd like to ask Bob to approach the podium here, and we're going to turn it over to him in just a moment. Bob Andrews is the Manager of Postclosure Safety for Bechtel SAIC, having previously served as the Performance Assessment Manager for the OCRWM program. In his current capacity, he manages and coordinates the technical investigations of the BSC Team, including the National Labs and support of science and performance assessment products for the license application.

Bob draws on over 20 years of experience in this area, and he's a Ph.D. in Hydrogeology from the University of Illinois at Urbana, Champaign.

Bob?

ANDREWS: Good afternoon. And, my personal welcome to the new Board members, and to the previous Board members, or consultants, good luck as a citizen. You're welcome back any time to ask whatever questions you might have.

As I'm going through this, I hope you will interrupt at any particular point if a slide is not clear, or the approach that I'm trying to portray is not clear, or the inputs to that particular part of the system are not clear. Because my objective is just to show you how, what's in the Total System Performance Assessment, the approach, the methodology and developing that Total System Performance Assessment, the requirements for it, which are important, because they do drive the architecture and the approach and the methodology, and some, if you will, interim feeds into the Total System Performance Assessment before you actually, if you will, develop the model and run it to do the postclosure performance measures of interest, of which there are several that we're going to talk about in here.

Before I talk about what I'm going to talk about, it's probably worthwhile to say what I'm not going to talk about, so there's no, hopefully, minimal confusion. As Mark said, we're not going to be talking about results. The process is that the model has been constructed, it's being reviewed, the calculations are being checked as I speak here today by a large group of people up in Summerlin, and, so, I will not present any of those results to the Board at this particular setting.

Another thing that I'm not going to talk about are all the process related aspects of the developing of the model, if you will, the quality assurance requirements and implementation of those requirements in the development of this model, the reviews of this model, including an independent model validation review team that reviewed the model, and the whole process of controlling the development of what is a fairly complicated model, piece of software and the models that are implemented in that software. So, I will not devote any effort to the process type controls on the development, testing and implementation, and actually results associated with the model.

The third thing that I will not talk about is some of the details associated with many of the inputs. I'm going to look at this from the, if you will, the 5,000 foot level of what are the major types of inputs into the TSPA. You will see when I get to that portion of the presentation, that I will, in bullet form almost, describe the technical bases, the scientific bases, the data, the tests, the analogues, the site specific observations, the laboratory information that supports that bases, but I will not in here describe that bases.

GARRICK: Bob, as we go along, would you be able to highlight the differences between TSPA-LA and TSPA-SR, for example?

ANDREWS: Yes, I will.

GARRICK: Okay.

ANDREWS: I do that, I have a couple slides at the very end, but I'll try to do those, filter those through the actual presentation.

And, my apologies in trying to produce this discussion, you know, I am well aware there are some very experienced members of the Board, some previous members of ACNW, very experienced and have been briefed several times on TSPA, and there are also, you know, some new Board members.

So I've tried to hit it at the right level. If I didn't, if I go too slow and you say speed up, because we're okay, then tell me to speed up. If I'm going too fast, you know, tell me to slow down. So, I tried to find a happy medium, if you will, recognizing the new make-up of the Board.

So, what I'm going to talk about in outline form, we'll keep that outline slide up there for a while, is what is the TSPA, a little bit of the history of how we got to 2004, the requirements that drove the TSPA, that drive the TSPA. And, when I come to that point, I will acknowledge that in the formal presentation, the slides are paraphrasing of the requirements. In the backup, the last 13 or 14 slides, are the actual quotes from the requirements, so from Part 63 and the appropriate subsection of Part 63, because those are very important, and sometimes taken out of context, they could be misinterpreted. So, I gave the actual quote from the requirement in the 13 backup slides.

Then we'll talk about the process for developing an approach, talk a little bit about barriers and features and components and distinction between those terms, the regulatory distinction between those terms, and the quality assurance distinctions for those terms, and the postclosure performance assessment distinction of those terms.

As you can imagine, when you have a series of requirements that you are showing an evaluation against, some specific terms have very, very specific meanings, and we have to use those meanings specifically as they are in the requirements, so I will talk a little bit about that, especially when I get to that barriers, features and components part.

Then, the bulk of the presentation is actual TSPA model architecture. So, walking through the system, I'm going to walk through the system as rain falls, and then the hydrologic processes, the thermomechanical, chemical processes that affect the alteration, degradation of the engineered parts of the system, and could potentially lead to release of radionuclides, and then the transport processes that affect the migration of radionuclides through the natural system, the engineered and natural system to the point of compliance, which we'll talk to when we get to the requirements part.

And, then, I do have a couple slides on the summary changes, and I will try to, as I'm going through, talk about those. I might miss something as I'm doing it.

Okay, we do have the next slide. So, on your third slide, we want to talk about what is the TSPA. It's a system-level analysis. We're evaluating the whole system response, not some aspect of just infiltration or just the package or just the waste form or just the saturated zone, but the whole system-level analysis. It does use numerical models. We unfortunately don't have a direct analog of a repository, so we rely on numerical techniques, numerical models.

Those models describe events, potential future events. You heard one of those this morning from John Ake, the seismic event, or other events that can occur at the mountain that have a probability of occurring. And a lot of natural processes, a lot of thermal processes, hydrologic processes, mechanical processes, et cetera, that can affect the performance of the system.

And, then, to evaluate that future performance out to some period of time. I think you had some discussion this morning about what that period of time is today in the requirements, in the regulations, and some potential changes in that time.

I want to point out that the models that are describing these events and processes are models that are based on the in situ observations in the mountain. I believe you're going out to the site tomorrow, or Wednesday, or sometime, so you can see some of those tests. Some of them are still ongoing. Others have been completed. It depends on what test you're looking at. A wide range of laboratory studies to evaluate material behavior in particular, and a wide range of environments, thermal, chemical environments in particular of all of those engineered and natural system components. So, we're looking at the integration of the individual piece parts to evaluate how they would behave over the next 10,000 years.

The last bullet is that the TSPA physically is a three volume document. Volume I essentially covers all of the inputs and the bases for the model. Volume II is the validation of that model. And, Volume III is the results of applying that model to postclosure performance, in this case, two principal performance measures we'll get to.

That is a basis, it's one of the bases for the license application. It's not clearly the sole basis, however. The license application, that which relates to postclosure performance aspects of the license application, has many other aspects in addition to the Total System Performance Assessment. In particular, it has aspects associated with barriers, and a description of the barriers and their capabilities and the uncertainty in those capabilities. It has a description of the features, events and processes that are relevant to evaluation of those barriers. And, finally, it has models and model abstractions and the bases for those models. And, then, you get to the TSPA and what's the dose, if you will, or concentration.

Let's go on to the next slide. I just listed some things of how TSPA has been used over the last 15 or so years within the project. First, and these are in no particular prioritized list, but it has been used to evaluate regulatory requirements. It has been used to look at margin and the capability of barriers. It has been used to identify what makes a difference and what doesn't make a difference, what's significant, what's not significant, what's high risk, what's medium risk, what's low risk.

We've used it for looking at design options and design alternatives. Some of those design options and alternatives, in fact, recommended by this Board back in the late, mid to late Nineties. Determine the significance of this uncertainty. And, I think I already mentioned the prioritizing risks.

Let's go onto the next slide. Okay, essentially what we're trying to do is answer some very fundamental questions associated with the long-term performance of this facility, what events and processes can occur, how likely are those events and processes, what are the consequences of those, and how reliable are your answers to the first three, i.e. what's the uncertainty you had in those first three, and how did you propagate or apply that uncertainty to the development of your models and the assessment of performance.

The TSPA takes the uncertainty and it propagates that. The actual performance measures of interest are risk type performance measure, its dose, where probability and consequences are multiplied, if you will. So, propagating the uncertainty and distributions of models and distributions of parameters and uncertainty associated with data, including the variability associated with particular processes across the repository block are important elements that have to be factored into the architecture, development and the actual Total System Performance Assessment model itself.

So, the goal is to use these ranges of parameters, ranges of models, and to propagate that through to an assessment of, in this case, dose or concentration.

Let's have the next one, John. Okay, at Yucca Mountain, Total System Performance Assessments of some color, with some degrees of assumptions and some degrees of simplification, and some levels of detail, have been performance from essentially the mid Eighties, mid to late Eighties. They've been reviewed several times by this and other Boards, including ACNW. NRC has, we've presented them to NRC on numerous occasions. In some cases, they've been used to address particular key technical issue items identified between NRC and DOE at the time of the site recommendation, the 293 key technical issues.

I think this Board is well aware that we're not the only ones performing Total System Performance Assessments. NRC and EPRI are on the agenda after me to present their latest risk insights and their latest applications of their system level models, which are totally different, separate, distinct from ours. We, of course, review each other's work to gain our own insights of how the system behaves for different sets of assumptions or approximations.

Our TSPA, DOE's TSPA has been peer reviewed formally twice, once at the time of the site recommendation by some fellows that are here in the audience, and that was the TSPA-SR, site recommendation, we called it, and then by NEA/OECD and International Atomic Energy Agency peer reviewed it on DOE's request in 2002. I'm sorry, the first one in 1999 was on TSPA-VA, the viability assessment. I apologize. And, the second one, the international peer review, was conducted on the TSPA for the site recommendation. Reports of both of those peer reviews are available.

The current TSPA is undergoing an independent, or has undergone an independent model validation review, a little bit different than a formal peer review. It's procedural aspects of model validation required in the procedures set, or one method of validating the model. And, that's not listed on here. It will be an appendix of the current document.

Next slide. Okay, I just have some quotes from the international peer review here. Generally, they agreed with the approach and methodology. They did have some issues on some aspects of it. You know, for example, that last bullet, while presenting room for improvement, was soundly based and implemented in a confident manner. There were a number of individual piece parts of the TSPA model where the international peer reviewers questioned the degree of conservatism that was being portrayed in the analysis at the time of the site recommendation. One in particular was the treatment of how water reacts with the waste, and the thermal hydrologic aspects of water/waste interaction once a package has degraded. But, you can read some of the rest of the quotes.

I think I have a slide in here of other international--I think the Board Staff asked to give a little bit of insight of what other nations are doing with respect to system type analyses. Not all other countries go to a probabilistic system type analysis, as is required in our regulations. But, some do. US, UK, Canada, Belgium, and the Netherlands do use essentially a probabilistic type approach. Spain, although probabilistic approach, is not their formal way of documenting system performance. They do do a lot of probabilistic sensitivity analyses to evaluate the robustness of some aspects of their models, and the significance of some aspects of their models.

A number of other European commission countries have used a total system type models and analyses and compared their approximations, simplifications in their total system type approaches, in a report that was published about two, three years ago.

Some other countries, Sweden, Switzerland and Japan, don't really rely on the probabilistic type approaches, but they do do what I'll call kind of one off type analyses, you know, what if I'm wrong on Model X, and it looks like this instead of this, what's the potential impact of that uncertainty on their assessment of how robust their repository system would behave. So, they've done some I'll call them limited probabilistic analyses, you know, taking an extreme case, or a one off case, and seeing how the system behaves.

So, as I say, that's kind of the last bullet there as well. For those that are using deterministic type approaches where it's one shot through models, they generally are doing sensitivity type analyses to evaluate what if they're wrong in any particular part of their model.

Next slide. Okay, this just runs through the DOE's TSPA's, down to the bottom one that we're on right now, which is the license application TSPA. I've just captured a few bullets, you know, trying to characterize the principal results of each of the TSPA's. I've probably understated many of them. But, they're there more or less to give you a kind of complete chronology of TSPA's. The earlier TSPA's, quite frankly, in '91, were kind of methodological based. They were looking at some parts of the system, and coupling some parts of the system in a probabilistic way, but other parts of the system were essentially deterministic, or very simple approximations of how that particular component or part or feature was implemented in the model.

This Board had a lot to do with the one in FY 2001, the Supplemental Science and Performance Analyses. I think in the end of 2000, the Board had some questions about unquantified uncertainties, and what are potential effects of those unquantified uncertainties. And, so, the Supplemental Science and Performance Analyses TSPA was essentially an evaluation of a wider range of uncertainties of potential effects on system behavior.

Let's go to the next slide. Okay, now, I want to go to the requirements, and my apologies to NRC for paraphrasing here. But, as I said, the actual quotes from each of the subsections are in your backup.

The first one is the requirements, these are the postclosure performance objectives, the repository must include multiple barriers, consisting of both natural and engineered barrier system. We're going to talk a little bit about that in a few slides, what are the barriers.

And, then, there's two performance measures, one is radiological exposures, i.e. doses to the reasonably maximally exposed individual. We're going to define that individual here in about a slide or two. And, the second one is radionuclide releases, essentially concentrations in the groundwater. That's the groundwater protection standard part. So, there's two key requirements. One is individual protection where consideration of likely and unlikely features, events and processes is required, and the second one is groundwater concentrations to assure that no undue damage to the groundwater resources in the accessible environment is a result of the repository. That includes only likely features, events and processes. So, there's a distinction between what you need to consider in individual protection, and in groundwater protection requirements.

And, the fourth one was in there is what happens if something happens to the engineered system, such as, you know, a human intrusion type event, a driller at the surface and it's prescribed in Subsection 63.321 and 322, exactly-- well, reasonably exactly, on how one should calculate, if they need to, the potential effects of a human intrusion event.

Onto 114 requirements. The parts that are really-- these are performance assessment. I probably should have a little time out for definition of performance assessment versus total system performance assessment. It can be used interchangeably. The requirements of performance assessment are shown here, (a) through (g). The Total System Performance Assessment is, if you will, the tool for analyzing--well, almost none of these, because it's the tool that's going to be used later on when I put the system together. But, all of the individual piece parts of the system, i.e. you've included data relevant to the geology, hydrology, geochemistry, including those that are disruptive events. And, assumptions, of course, is it's site specific data, it's not just, you know, some site somewhere else. It's Yucca Mountain data related to those processes.

That accounts for uncertainties and variabilities. TSPA does have a back end part of that, but uncertainty and variability in processes, parameters, data, actually occur at the individual process parameter level, and then are propagated to the TSPA.

Consider alternative conceptual models of features and processes. That also happens more or less at the process level, understanding level of the performance assessment, not Total System Performance Assessment. For example, you know, alternate thermal hydrologic characterizations, or alternate characterizations of how moisture is distributed inside the drift, once the drifts are loaded, as a function of time and space, those alternative conceptual models can be readily and appropriately addressed at the process level where you're modeling those kinds of processes, and looking at the data associated with those kinds of processes. The TSPA can evaluate the significance if there is uncertainty there of those processes and process understanding on the behavior of the whole system. But, the actual evaluation of alternative conceptual models generally occurs at the process level.

Consider only events that have at least one chance in 10,000 of occurring over 10,000 years. So, this is the definition of unlikely, or the boundary--well, we're going to see later on the boundary between likely and unlikely. So, this is one place where, if you want to define the term unlikely and likely, you can go to Part 63, and you can be very precise on that distinction between those two terms, which you might loosely use in your common everyday language. But, in this repository for this system, there are very discrete terms defined for the definition of likely and unlikely.

Okay, provide the technical basis for inclusion or exclusion of features, events and processes, including those in (f), the features, events and processes that relate to degradation, deterioration, alteration of engineered components of the system, the engineered barrier system.

And, then, finally, provide the technical basis for the models. So, a lot of this relates to the basis for the models, the basis for the processes that you've included, the basis for the processes that you've excluded, and events that you may have excluded, the treatment of uncertainty and the propagation of uncertainty, et cetera.

Going onto 115, this is the barrier requirements. Identify the features that are considered barriers important to waste isolation, describe the capability of those features, taking into account the uncertainty. So, even in the barrier description and the barrier capability, evaluation, there is uncertainty in how that barrier may perform. The uncertainty associated with the characterization of those features and components that contribute to barriers. And, then, finally, provide a technical basis for the description of the capability.

Let's keep moving through the requirements base. By the way, especially for new Board members, and I apologize to ACNW ex-members. All of these requirements are embodied in NRC wrote a site specific review plan for the license application. The Yucca Mountain Review Plan finally published in final form, I don't know, a year and a half ago, or so. And, in that review plan, it is very explicit, essentially model by model, part by part, requirement by requirement, on the Commission's expectations of the Department of Energy, assuming the Department of Energy submits a license application on Yucca Mountain, which I think as Margaret and John told you this morning, is still the intention of the Department of Energy.

So, the Yucca Mountain Review Plan is really the basis for how the license application will be reviewed. And, I'm sure Tim and others from NRC will, if asked, expand on how they intend to use the review plan. So, all these requirements essentially find their way into the review plan and the review criteria, the review methods that NRC staff and Commission will use once the license application is submitted.

Now, I come to the individual protection requirements. These are towards the back of Part 63. First, we have the 15 millirem per year dose for that 10,000 year time period. It's to be calculated for a reasonably maximally exposed individual. So, we've defined the person for which the dose is to be calculated. It's not conjecture as to who you're trying to protect and how you're going to calculate this thing. It's been specifically defined in the requirements base.

It also defines how much that individual should drink of water from the ground. It also defines an annual water demand in the representative volume in which the concentrations are to be calculated. So, there's a nexus, if you will, at that 3,000 acre feet per year between the individual and groundwater protection requirements of Part 63, and we'll come to the groundwater protection requirements in a second.

Part 63 says the peak dose after 10,000 years shall be evaluated in the EIS, and they were evaluated in the EIS.

The final environmental impact statement is out there. It's been out there for a couple years, and there are some peak dose analyses in that final environmental statement.

And, it also says you only need to consider, if you will, the FEPs, the features, events and processes, that are more likely than one in 10,000 in 10,000 years. So, one part in 10^{-8}, if you will. So, when John Ake was presenting this morning down to 10^{-8}, this is the reason he was going down to 10^{-8} per year, because the requirements drove him to look at 10^{-8} annual recurrence intervals.

Next slide. Groundwater protection. Now, we're protecting the groundwater resource, and there are some concentration limits for radium and for alpha emitters, beta and gamma, based on an assumption of two liters a day in a representative volume. The representative volume happens to be located about, or the controlled area boundary, about 18 kilometers south of the repository. There's an exact, I think I have it in the backup, the exact longitude or latitude, I always get those two confused, where that boundary shall be within.

And, now, here is a slightly different definition at the bottom one. Exclude FEPs less likely than one in 10. So, now, all of a sudden--in 10,000 years, so 10^{-5}, not 10^{-8} anymore, per year. So, this is the definition of boundary between likely and unlikely. So, if I screw up over the next hour between those likely and unlikely, then shame on me. But, it's a very clear distinction in the requirements base between those things that are likely, and, therefore, need to be considered in groundwater protection evaluations, and those things that are unlikely, therefore, do not need to be considered in groundwater protection, but do need to be considered and evaluated and quantified in individual protection. And, conversely, those things that are very unlikely, the boundary is 10^{-8}. So, things that are very unlikely, may be excluded from consideration in the Total System Performance Assessment. So, I now have discrete definitions of three very loosely used words sometimes.

Next slide. Okay, the human intrusion standard is similar to the individual protection one, except it says either evaluate the need to evaluate the effects of the repository system, given unlikely human intrusion event, only if it wouldn't be recognized by the drillers. Those of you who read the site recommendation realize we said the driller we thought would recognize the fact that they tried to penetrate a drip shield and penetrate a waste package. Therefore, there would be no need to consider this within the 10,000 year regulatory time period. But, you would have to evaluate it as part of your peak dose evaluation, which is what it was in the final environmental impact statement.

Next slide. Okay, I think Rick Craun gave some design type pictures this morning. I've just thrown in a couple more for the purposes of the new Board members. The repository, I think you'll have a chance to go out to the site in the next couple of days, would be located about 300 meters beneath the ground surface, about 300 meters above water table, and I'm giving nice round numbers. It's variable depending on topography, and it's variable depending on location within the repository block. But, reasonably, it's 300 meters to the surface, and 300 meters to the groundwater table.

You see the reference repository design layout, essentially consists of five and a half meter diameter drifts. Waste package is placed inside the drifts. The waste packages vary in diameter, depending on the waste package type. I think I'll have a picture of that in a second, which generally depends on the waste form type. But, all waste packages are stainless steel for structural support, 10 centimeters, and 2 centimeters of Alloy 22 on the outer ring of the package for corrosion resistance.

Then, there's a drip shield, titanium drip shield, placed on top of that. You see some of the artist's renditions of the emplacement modes here. The packages are in the current design, as Rick maybe talked to you about, the subsurface design a little bit, are about 10 centimeters apart. So, we've called that the line load from a thermal management perspective, an issue that's been of some interest to this Board in the past.

Next slide. Here's one picture of a package. It happens to be a commercial spent nuclear fuel package, 21 pressurized water reactor assemblies, sitting in the middle, the length is about the length of a PWR assembly, so 5 metersish, plus or minus, and the diameter is, you know, 1.8 meters for this kind of a package. For some other packages, it's going to be a little bit larger diameter.

Now, you also see the closure lids and the welding that will go on in the closure lids. There are actually three closure lids. One is the stainless steel inner vessel closure lid, and then you have two Alloy 22 closure lids on the outside of that. And, there are stress mitigation techniques being employed for the outer closure lid, and not for the middle closure lid. That is a little different for the license application design. There were stress mitigation techniques applied to both lids, the middle and outer, for the site recommendation design, but for the license application design, it's one stress mitigation technique applied on the outer lid. But, generally, the design is essentially the same.

The repository design that I showed on the previous layout is a little bit different. It's just configured a little bit different. It's the same from a thermal perspective, from a thermal management perspective. It's just a little different on where, and the fraction of the repository that's in the lower lith and the fraction that's in the middle non. So, those fractions of rock type for different lithologic units for different parts of the repository are a little bit different in the license application than they were in the site recommendation.

Next slide I think shows the different waste form types. So, we have on the left-hand side, commercial spent nuclear fuel waste form types, which is 90 per cent of the inventory by mass, by metric tons. The license application is for 70,000 metric tons, I think Rick probably told you that. So, 63,000 of those 70,000 are commercial spent nuclear fuel. Different types. Some of it's boiling water reactor, some of it's pressurized water reactor.

Then, there is glass waste forms, high-level waste forms and DOE spent nuclear fuel waste forms, of which there are nominally 250 types, but the largest fraction by far is Hanford. And, then, finally, the Naval waste. There are, in the license application, approximately 300, I believe, Naval canisters, Naval waste packages.

I think if it didn't come up this morning, the Navy for I think what should be obvious reasons, does their own source term evaluations, and their own criticality evaluations. Those evaluations are independently reviewed by the Nuclear Regulatory Commission. They will be submitted, I believe, at the same time as the Department of Energy's license application. So, it's one complete package. But, that information, the Navy information of course is all classified with respect to its waste form types and characteristics.

Next slide. I think I'm going to start finally getting into, okay, this slide also--doesn't this slide appear in the other screen, too, or not? Yeah, okay.

So, now we're--are there any questions on the background type stuff? Because this might be a time to at least--

ABKOWITZ: Actually, what I was going to suggest is that you continue through Slide 26, and then we'll pause for questions then.

ANDREWS: Okay.

ABKOWITZ: At the pace we're going, we will have exhausted half the time and we will have gotten through a third of the slides. So, we can pick it up after that.

ANDREWS: So, it's working.

ABKOWITZ: What's that? Me or you?

ANDREWS: Okay. What I tried to do here is, in one slide, and we're going to keep this theme going through about the next 50 or so slides, is the TSPA is a central part of performance assessment. But, there are other parts, you know, of performance assessment.

In the upper portion of this, there's first off, the initiation, the identification of the relevant FEPs, features, events and processes, that may act on this repository system. And, there's an evaluation of those features, events and processes. Events usually work on features, and processes work on or within features. There's evaluation of those to see which ones need to be included and which ones can reasonably be excluded from the Total System Performance Assessment model.

So, what, what we've called FEPs screening, first off, the identification of the FEPs, the very upper part, the Nuclear Energy Agency, NEA, has an international data base of features, events and processes for all repository environments that's been developed over the last 20 yearsish of time. We use that as one of our major inputs for our development of the list of potential FEPs.

We then evaluate. Some of those are, of course, irrelevant because they might have been for a salt repository, or for a sea bed repository, or some other kind of repository. But, a lot of them are relevant to Yucca Mountain and to a wide range of possible repository environments.

There are additional FEPs that are kind of Yucca Mountain specific FEPs. The US right now, anyway, is the only nation looking at unsaturated zone, so repository in rocks above the water table. Every other site is looking at repositories, potential repositories, in zones below the water table. Of course, not very many other places have 600 meter deep water table either around the world. So, there's reasons for the differences. But, because of that, there are some differences in the international FEPs list and Yucca Mountain specific FEPs have been identified and used to enhance the identification of FEPs.

But, there's an evaluation of screening. They can be screened on probability, clearly, 10^{-8} is one screening criteria. It's very unlikely, therefore, no need to consider. Or screened out on it's insignificant to the propagation of dose to the reasonably maximally exposed individual. Or regulatory basis, for example, number of human intrusion, in international community, human intrusion type FEPs are a significant deal. We, thank goodness, NRC and the EPA, EPA before NRC, and then NRC said we're going to specify this human intrusion scenario. So, we're going to take it out of speculation and make it a requirement, an explicit requirement in the regulation. So, the need for some aspects are included on that basis.

The need for other aspects of conjecture associated with human behavior are also excluded by the requirements that are written in Part 63. So, there's different reasons for excluding a particular feature, event and process.

Once then are determined to be in, i.e. we need to then evaluate the consequence and risk, dose, associated with them, we've lumped things into three what we've called scenario classes, mostly driven by the initiating conditions. The primary scenario class is what we've called the nominal scenario class, which generally applies to things that are most likely expected to occur over the next 10,000 years, thermal aspects, mechanical aspects, chemical aspects, hydrologic aspects that we expect the system to evolve through over that time period.

The other two scenario classes are destructive, i.e. an event occurred, a discrete event occurred, either a large seismic event, or an igneous event, unlikely though it may be, and we have to evaluate then the consequences and risks associated with those unlikely events. Seismic events in fact are an interesting one because they cover the gamut from likely to unlikely. It is likely that we will have a 10^{-4} or 10^{-5} recurring interval seismic event in the next 10,000 years, so we should evaluate the risks and consequences associated with that.

However, igneous, and we'll show the numbers and the basis for those numbers here in a little bit, those are unlikely, not quite very unlikely, but unlikely to occur over the next 10,000 years.

And, then, the rest of the system in this portray, this little cartoon, the wheel, as it's sometimes called, are the individual piece parts of the system. And, we're going to walk around those piece parts here in subsequent discussion to give you how ultimately you take water at the surface, and you could get to a dose to the reasonably maximally exposed individual. And, then, the changes associated with that, associated with igneous and seismic events.

As I said, there's two principal performance measures. There's the dose performance measure, and then there's also to the groundwater concentration performance measure.

Okay, next slide, John. Okay, I should have said at the very beginning--well, I think I did say I'm not going to talk about the fundamental underpinnings of all of the TSPA. There's essentially, I think maybe John might have talked a little bit about the analysis and model reports, and the status of the analysis and model reports. There are approximately 100, the actual direct feeds is a little less than that, if I throw in some indirect ones, it's probably a little more than that, but nice round numbers, approximately 100 analyses and model reports that include the data, description of the data, the parameters, the uncertainty in the data and parameters, the evaluation of the features, events and processes, et cetera, that ultimately go into the TSPA model itself.

What I've tried to do here is talk about the piece parts of the TSPA, more at a conceptual level, not in a how it's exactly documented and what analysis model report does seepage occur, for example, and where did we describe what we think is the likely seepage at Yucca Mountain, and the distribution on that seepage. There's, in fact, about three AMRs where that, analysis and model reports, where that seepage issue is discussed.

So, these are the fundamental building blocks of the TSPA.

Next slide. I talked a little bit about this, I probably should have waited until I got to this slide. So, we started with this Nuclear Energy Agency data base of FEPs. We added to it, modified it a little bit, modified some of the descriptions to be specific to Yucca Mountain. We did a little bit of combination, if there was some redundant FEPs, we put them into one common FEP category and one common FEP, so it would be evaluated that way rather than individually. And, we made some site specific FEPs.

And, then, we used our criteria for either saying we need to include this FEP and develop the model for that FEP, or we can exclude that FEP, and here's why we can exclude that FEP, either based on, or generally based on either probability or by significance, its consequence is insignificant.

Next slide. Okay, this kind of does in words what I tried to do with the wheel. So, we identified the FEPs, we developed the scenario classes. We can screen on scenario classes as well when you agglomerate a series of features, events and processes together, it is possible to screen on that agglomeration. In fact, NRC expects the evaluation to be that agglomeration level rather than the eaches level, because that would be inappropriate, exclusionary mechanism if you got down to the detailed aspect.

You can imagine the example might be igneous events, and I hate to use that because I think it's going to be two days for ACNW on Tuesday and Wednesday, but if you said what the event was, was the probability of the event occurring on one day in one year, and that was what you were going to use for your screening criteria, then that probability is very small, and you might inappropriately screen that out. But, if you said what's the probability integrated over time, and now can I screen it out, and the answer is no, based on probability grounds.

So, I think we can go over to the next slide. Maybe this is where you want to break, Mark, or do you want me to go through these?

ABKOWITZ: Do the next three, and then we'll break.

ANDREWS: Okay. What I've done here in this slide, and the three that follow, I think you can go onto the next screen, John. Okay, remember that definition of barrier that's in Part 63, and I think I maybe have it only in the backup, to be honest with you, I didn't put the definition of barrier in the main body of the presentation. The definition of barrier in Part 63, and I'm going to paraphrase it, so Tim can correct me when I get it wrong, is any feature or component that can substantially reduce or eliminate the contact of water with the waste, or any feature or component or system that can substantially reduce the rate the radionuclides are released from the waste, or transported to the accessible environment and to the reasonably maximally exposed individual.

So, there's essentially two parts of it. One is a water contacting waste part, amount and rate of water contacting waste, and one is a transport time, release and transport time. So, we have those two aspects that define barrier capability.

You'll note that in those definitions, the word TSPA doesn't come in, nor does the word dose come in. It's water and it's radionuclides. Those come in. And, it's rates, not concentrations or doses. So, there's a distinction here now between the barrier concept and individual protection and groundwater protection.

They also say they have to be consistent. So, your treatment of barriers, DOE, shall be consistent with your treatment of the models that contribute to those barrier performance that you use in your evaluation of individual and groundwater protection. So, there is a nexus between those two, even though they're looking at different aspects of behavior.

So, you essentially have three barriers in the next three slides, using those definitions. One is associated with features above the repository horizon, at the repository horizon and below, and those features essentially reduce the amount of water that is at the land surface from contacting the engineered barrier system. And, that's a number of processes going on that we're going to walk through later on when we talk about models, but those processes are surficial processes, and those processes are capillarity type processes at the drift wall rock interface. So, I've listed some of those processes here in the two cutaways associated with the upper natural barrier.

The features, now I'm going to walk between features and system, structures and components, so I'm walking between natural system type nomenclature and engineering system type nomenclature. So, for those of you who are of the engineering sorts, you might just translate my word feature to component, if that's what is more comfortable for you.

Structure, system and components have discrete quality requirements, though, so they have to be treated in a very different way in the license application itself, and all kinds of post license application activity. So, there's is very distinct quality assurance aspects and procurement aspects that are very different for structure, systems and components than they are for features of the natural system.

But, the features of a natural system that affect this upper natural barrier are the surficial soils and topography, and the unsaturated zone essentially above the repository and down to and including the repository host horizon.

Next slide, John. The engineered barrier system, which now has several components to it, the drip shield, the package, cladding, the waste form, and in fact the invert itself are components. They're also features, but let's use the engineering language when we get into the engineered aspects of the system. Those are components that contribute to either (a) reducing the amount of water that can contact the waste, or (b) reducing the amount of radionuclides that can be released from the engineered barrier system and that may be potentially then transported. I think this is probably okay on the engineered barrier system.

Let's go down to the lower natural barrier. So, now I'm in the rocks below the repository horizon, the 300 meters or so of unsaturated zone rocks, down to the water table, and the 18 kilometers or so distance directly beneath the repository in the saturated zone, down to the accessible environment, and the point of compliance with both individual and groundwater protection requirements.

So, the features are those two features, natural features of Yucca Mountain, and the function they provide clearly is to reduce the rate of radionuclide migration from the repository horizon to that 18 kilometer point.

I've put some aspects of those features and some of the processes going on within those features. Those processes, you know, are different for different types of radionuclides. For example, the possibility of colloidally transported radionuclides needs to be considered in both the unsaturated zone and the saturated zone.

I probably should, this schematic on the left doesn't quite do justice to the topographic change from the repository horizon to the 18 kilometer point. The water table is quite flat, but the topography is not very flat out there. There's significant gradient and topographic elevation as you go from the repository block down to 18 kilometer point. So, there probably should be more of a cutaway showing that geomorphic change at the surface of this particular conceptual drawing. But, I think it serves to illustrate the processes that are acting in those aspects of the system.

When we get to saturated zone, we'll talk a little bit about the saturated zone characteristics of the volcanic tuff versus the saturated zone characteristics of the alluvium. One could have, I suppose, made those separate features, but, in fact, they act in concert, so they're indicated as one feature called the saturated zone.

Okay, next slide. Now, this might be where you want to break.

ABKOWITZ: This is where I'd like to break.

ANDREWS: Okay.

ABKOWITZ: Give the Board and Staff a chance to ask questions. I'll kick things off.

If we could go to Slide 11 for a moment, please? I was looking at Item (d), consider only events that have at least one chance in 10,000 of occurring over 10,000 years. And, I presume that that's a very important criteria that was applied to the FEP process, so is there an effort going on right now to go back to the FEP process and rethink how changes in the assumption under (d) might change the way TSPA is being formulated?

ANDREWS: For what reason?

ABKOWITZ: For the reason that you may need to be looking at occurrences over more than 10,000 years?

ANDREWS: Oh, you probably should ask Tim. I hate to punt like that, but the regulation is the regulation right now.

MC CARTIN: Yeah, Tim McCartin, NRC. The standard was remanded for compliance period of 10,000 years. The 10,000 years here was not labelled in terms of the compliance period. So, you know, I'm not a legal authority, but it wouldn't translate that that 10,000 years was remanded. There was nothing in the standard that said that would change, as far as I read it.

ABKOWITZ: Okay, thank you. Questions? Howard?

ARNOLD: Arnold, Board.

I'm interested in the data you used for failure of the zircaloy clad, and release rates from the UO2 pallets for commercial fuel.

ANDREWS: Can we, because there will be a couple slides on that, can we just wait until we get to--I mean, I appreciate it and I'll try to be more specific when I get to those slides on those. Generally, it's based on lab data. Zircaloy industry, of course, has a wealth of data on zircaloy in a range of environments that we've benefitted from. Site specific, you know, project generated data on zircaloy degradation has been somewhat sparse. We have some, but mostly we've relied on literature and, in fact, the Navy's testing of zircaloy, which there is a wealth of information on.

ARNOLD: Also release from the UO2 pallets.

ANDREWS: Yes, those are based on lab data, so I'll come to that when I get to them.

ABKOWITZ: Okay, we have Ali and then John.

MOSLEH: Mosleh, Board.

The first question is actually on establish a frame of reference for myself. I understand the way you describe it. TSPA is essentially a PRA process. I'm sure this question has been asked and answered in the past, but is it, in your mind, yes?

ANDREWS: I think essentially, it's very analogous. You have an evaluation of, you know, those components that you are, if you will, relying on in a PRA, and those that you've chosen not to call safety class, you know, type features or components, I guess they call them in the design world. So, that would be analogous kind of to our FEPs process, and evaluation of relevant features, events and processes.

I think the propagation of uncertainty through models and parameters and data through to the assessment of a range of possible outcomes is also, you know, very analogous. I think the, if you will, the post-processing of results, you know, to evaluate what component in the system was most significant, you know, where do I need to put my margin, et cetera, those are somewhat analogous.

I think we may disagree sometimes when we get into a particular detail of any particular implementation of some component or feature, and how it's been characterized, and have you propagated all of the uncertainty associated with that particular feature or component or parameter through the analysis. You know, I don't know which one is more complex, you know, to be honest with you. I think they're probably both fairly complex type analyses, but there are a lot of similarities.

MOSLEH: Now, in relation to one of the steps in the process, FEP selection, initial selection, you mentioned in the NEA list, was there any conceptual or method model behind the selection? I'll give you an example, the power reactor, PRAs, we use, for instance, for internal events, the heat balance as a principal. You know, if you don't have the heat balance, you have a potential core amount, but was there a model similar to that here applied to identify, delineate the initiating events, or the FEPs?

ANDREWS: Not at the--at the identification stage, there was an attempt not only with the NEA data base, but in previous iterations of the FEPs that we thought were relevant, or potentially relevant, there were interactions with the NRC Staff. There's one or two KTI agreements that specifically relate to FEPs identification and FEPs evaluation. But, there wasn't any--and, so, there is a completeness test of, you know, cross cutting processes with features and events, and features. But, I think maybe what you're describing is more when we come down to a model that describes, you know, a feature, or describes a process, or describes an event acting on a feature, then we would have more of the did you capture the physics and, you know, conserve mass, et cetera, more involved in the decision making between alternate models. But, at the identification of features level, there wasn't any overlying constraint, I don't think.

ABKOWITZ: John?

GARRICK: Yes, just to add--

ABKOWITZ: Would you identify yourself, please?

GARRICK: Excuse me. Garrick, Board.

With respect to the question about the difference between PRA and TSPA, one area where there's a major difference is with respect to the notion of scenarios. In a power plant, PRA, a scenario is generally taken to be a pathway through an event train, of which there may be hundreds, thousands, and even millions. That concept is not applied here at all.

The concept here is one of FEPs, features, events and processes, and sorting the FEPs and screening them, and then aggregating those into general scenario classes. And, of course, this is one of the things that I have commented on many times. It makes the transparency of the TSPA very difficult. The transparency of the nuclear plant PRAs is pretty clear because of the way the scenarios are structured. You can see exactly what the initiating events are. You can see exactly the paths that take place. You can see exactly what intervenes, and you can see exactly where it ends up. That's a very much more difficult process here. So, a PRA is basically a structured set of scenarios. A TSPA is not, at least in the same sense. So, that's one major difference.

Now, my question, Bob, you mentioned earlier that stress mitigation techniques were implemented with respect to the lids and welds and so on and so forth. And, of course that is an issue, because of failure weaknesses, and so forth. Now, what about the impact on those mitigation techniques of the handling operations in the surface facilities? Because you're going to be doing some operations that are going to be different from the original packaging, I would guess, in the surface facilities. Are you going to attempt to have the same kind of processes in the surface facilities with respect to vulnerable components, like welds and lids, and what have you?

ANDREWS: You mean with respect to preclosure safety analyses, or what?

GARRICK: Yes, preclosure. Well, what I'm concerned about is the failure modes, and one of the areas that we talk about a lot are the lids and the heat treatment of the welds, and what have you, when the waste packages are first loaded and prepared for transport. But, what events can we imagine that would compromise that whole process? And, one event that you might imagine that could compromise that process is activities at the surface facilities.

ANDREWS: There was an assessment, now, I'm talking about the postclosure aspects of the assessment, not the preclosure aspects of the assessment, but there was an assessment of handling aspects, not only fuel handling, but package handling, the actual doing of the welds, doing doesn't sound very technical, but the actual welding process, the mitigation process, and any undetected failures or features associated with that process.

So, this analysis considered industry standard type evaluations of failures, if you will, where failure now doesn't mean necessarily failure of the package, it means failure of that stress mitigation technique or failure of the weld flaw detection technique. So, there's distribution of weld flaws, distribution of handling type, including stress mitigation type operations, that are propagated into the postclosure assessment. So, it in fact results in a probability, albeit low, but a probability that needs to be considered of what we call early package damage, or early package failure as a result of some of these handling, welding, stress mitigation processes that do occur, you know, at the surface.

GARRICK: What I was getting at is more of an operational question than what you assumed in the TSPA. I was really trying to get at what rules are being set down for handling operations in the surface facilities that sustain, if you wish, the integrity of the waste packages throughout the process, and how are you accounting for this in your TSPA?

ANDREWS: Well, how you accounted for is how I said. The actual operational aspects probably Rick would have been, I don't know if he's still here or not, but we do have a design PA, if you will, interface document and interface drawings that specify not only what we used as our bases for particular interface issue like this, and there are many others, as you can imagine, between the design and postclosure performance, such that any deviations from that, you know, during the operational phase or, you know, furthering the design, and I think Rick probably told you where we are in the design process, can be evaluated appropriately. So, both of those interface drawings, and interface documents that make that nexus, if you will, between the postclosure basis and the design operation facility at the surface.

GARRICK: Just one final question. Are you in a position now where you can be very quantitative about the pathway of material from the waste package through the saturated zone? In other words, are we able to identify specifically how the distances and areas of saturated alluvium, for example, that the material has to pass through, et cetera? I haven't seen a pathway really calibrated that would give a clear indication of what the media is and how much is involved as the plume progresses. Are we able to do that now?

ANDREWS: Yes, we are, but there is uncertainty, as you can imagine, in all aspects of that. And, I think we presented some stuff to this Board, not to your previous Board, but to the Nuclear Waste Technical Review Board in April, where we looked at uncertainty in the characterization of the alluvium/bedrock contact. And, it's a lot better known now than it was in SR, but still with some uncertainty, where we looked at flow paths and flow directions, which are reasonably well constrained by a lot of independent lines of evidence, including geochemistry and some isotopic observations, but still with some uncertainty. And the kind of a nexus between those two, you know, flow paths and where they are, or likely to be, and geologic information, and where that boundary is or is likely to be, have been incorporated into the saturated zone models and analyses.

GARRICK: Well, I think this gets very important if you really want to get a good handle on the retardation features of the site.

ABKOWITZ: We'll have David and then Leon, and then we'll need to press on. David?

DUQUETTE: Duquette, Board.

Looking at 63.114, Item (c), that's a very open ended statement obviously, because you can either treat it perfunctorily, or you can do something in detail about it. And, in the two years I've been on the Board, and I haven't spent enough time on TSPA, frankly, but it doesn't look to me like a lot has been done with the alternative conceptual models, or at least let me rephrase that, and say they haven't been presented to the Board as alternatives, and what the results might be. Can you comment on that, please?

ANDREWS: Yes, I think I'd like to, you know, because within the TSPA, this is performance assessment now, not just the Total System Performance, within TSPA, the only thing it can do, if you will, with an alternative conceptual model is just evaluate its significance. And, if both are reasonable alternatives, at least from the observations that have been made with respect to that particular piece part of the system, then does it make any difference which reasonable alternative effects on dose. And, if there are multiple reasonable alternatives and there's no way to distinguish between those alternatives, i.e. one's more likely than the other because of, you know, some observations or tests or inferences or analogues, or whatever, then the TSPA process would include the one that's more conservative.

The other approach could have been on such things, go out and either gather more information, determine which one is the more appropriate alternative, or go out and talk to some experts and elicit them and weight the alternatives. But, in the absence of the ability to weight alternative conceptual models within a system type concept, you're left with kind of using the more conservative of multiples, if there are equally likely multiples. So, from a TSPA perspective, it's--you're kind of at the tail end of evaluation of alternate conceptual models.

If I look at it in an imaginal piece part, you know, of the system, you can look at alternate conceptual models, and multiple alternate conceptual models do exist. If I just take the example that Dr. Garrick raised, although I'd love to go back to some examples we had in May, but I think I'll stick with saturated zone examples right now, there are alternate conceptual models out there that there's potential for retardation, significant retardation of some oxygen dependent radionuclides, like technetium, in the saturated zone if you can convince yourself that alternate conceptual model of significant reducing conditions in the saturated zone exist.

There are observations of reducing conditions in the saturated zone. There are observations of oxidizing conditions in the saturated zone. Both of which, reasonably along likely flow paths. The approximation that we have used, we've used in the past, I think we presented it to the Board in April, when the saturated zone had a full day on the docket, was go conservative, go with the it's oxidizing, rather than try to take, if you will, credit for the potential alternate conceptual model that it's reducing.

So, I think, although I'll agree with you that when we sometimes present information, we maybe don't flag it and say here now is an alternate conceptual model associated with process X that we are going to have to describe in the license application, and these are requirements now for the license application. We more present it as, well, we have alternate interpretations, and alternate representations, and we've chosen this one because. But, there, I think you could find a myriad of examples of alternate conceptual models that almost process by process that have to be evaluated, and discussed, and potential significance of them, or insignificance of them at least documented, you know, in the process. So, we maybe don't flag it with big neon letters when we present it that way.

DUQUETTE: Duquette, Board.

Just one example with the seismic problem, and by the way, there was, as you know, an earthquake not very far from here yesterday, or the day before yesterday, in California. But, I could conceive of a conceptual model that said there's one in 10^{-9} probability of a seismic event, but if one occurs, then I've got a disaster. And, so, those are two extremes, and I understand how you take many of those into consideration, but I think it might be interesting to point out to the Board once in a while why you've rejected certain concepts, for example, or how you've gone conservative, what you've had a tendency to do. And, this isn't a criticism of what you've presented at all.

But, because of time limitations, what you've had a tendency to do is indicate your best model rather than some other possible models that you have not looked at or have discarded because.

ANDREWS: Good point. Thank you.

ABKOWITZ: Also, because of time limitations, we're going to move on to Leon's question.

REITER: A follow on to Dr. Duquette's question about alternate conceptual models, maybe you go over the rationale why in the PVHA and PSHA, there are many alternate conceptual models used, and they were weighted, and why that approach could not have been applied to other elements in the TSPA, or why you couldn't follow the approach you had in the alternate conceptual models, and apply that to the TSPA. There's two distinct treatments and I'm trying to get, does it mean anything, is there a problem to approach it in two different ways.

ANDREWS: I mean, other things could have been treated that way. I think it's just there was a recognition that for these unlikely events, such as igneous events and high consequence, high magnitude, you know, seismic events, you know, the tens of centimeters per second PGVs kind of values, or hundreds of centimeters per second, the one is you don't have, if you will, direct observation. I mean, you have inferences you can rate on the past of igneous activity, on the past of seismic activity, but you are trying to propagate that past insignificantly into the future.

So, for such events, and I believe there's a, what's it called, the SSHAC report, which is a joint EPRI/NRC and somebody else was involved with that--oh, DOE, that talked about the use of, you know, expert elicitations and in particular, that report was regards to seismic expert elicitations, on trying to project futures, and I think they concluded that for those kinds of event based, I was going to say event based processes, but I don't want to confuse it, events, that going to experts and reasonably trying to quantify uncertainty from experts rather than from direct observation is a more appropriate way to go.

For other events, I should point out, and let's not call climate change an event, I'd like to call climate change a process, although some people may consider it event, it's very likely that the climate will change. The uncertainty is more on the win, and how much the climate is going to change, not whether it is or is not going to change. Whereas, in the seismic and igneous, it was very uncertain about the win, and the probability. So, expert elicitation was used.

But, there's nothing to preclude expert elicitations in any propagation of uncertainty, weighting alternatives, evaluating the most reasonable, developing parameter ranges, or whatever, there's nothing to preclude it. It just has not occurred. It is a very lengthy, time consuming process, though, to elicit experts, and have it fully documented in a quality way.

ABKOWITZ: Thank you. Before we resume, I wanted to recognize another recent private citizen who served admirably on the Board until he left the Board a couple months ago, and that's Dr. Dan Bullen. Dan, could you identify yourself, please? Thank you.

Dan is another colleague that many of us have grown to admire and work closely with and appreciate what he has brought to the Board over the years. And, I do remember my first meeting as a new Board member, and we were sitting in one of these day long events, and after the first presentation, all of a sudden, this guy grabs this microphone and says, "Bullen, Board," and I thought, gosh, it's not his Board.

But, Dan has been very passionate and very knowledgeable, and we've learned a lot from him. And, I was going to suggest that perhaps he can define a new unit of measurement called, "The Bullen," which is some metric that's a combination of passion and focus, and perhaps he can evaluate the Board members on that basis, and let us know how we're doing.

I'm going to return the floor back to you, Bob, but I do want to point out that you've got about 40 minutes to cover 60 slides, but I do also want to point out that the new members went through a pretty extensive educational session yesterday, and they are somewhat knowledgeable on the sub-components of this process. So, you can use your discretion to decide where you want to land and where you want to, you know, brisk along. But, that's the game plan.

ANDREWS: Okay.

ABKOWITZ: Thank you.

ANDREWS: The test will be at, when, 4? It will be open book. Okay.

What I want to do now is walk through the system. I'm going to start with the nominal, what we expect to occur, and then go onto igneous and seismic. And, what I've tried to do in the following viewgraphs is first have--try to keep you focused on where we are in the system. So, if we're going to come around the wheel, there's a lot of things, one of the main purposes of TSPA, of course, is to integrate a large set of information, multiple processes acting at the same time that can affect repository behavior. So, you need to have a sense for the inputs and outputs as they're going around the model. Then, to show what I've called an information flow logic, which includes on it a box there that says what's the major inputs, what's the major outputs, and what is the fundamental key aspects of the basis behind that box.

Then, I'm going to have a couple of slides that are either conceptual in nature of what are the processes going on, or some kind of representative intermediate result. So, we're going to use both screens here to walk through the system, so let's start with the next slide, okay, let's start with the unsaturated zone above the repository. Next slide, John. And, what goes on there. The climate happens, and it does change, and climate does affect the amount of water that can get into the repository block, if you will.

Of course, there's some conjecture about how you propagate climate change in the future, so there's an analysis associated with that climate change.

Next slide. On the infiltration, this is the amount of water that can--the precipitation at the surface, the amount of water that can get into the ground and stay in the ground, i.e. not be evaporated or transpired or runoff or whatever. Here, there is a lot of site specific information on infiltration. The USGS did by far and away the bulk of this work. The model that we're using is very similar to the model that the USGS uses for evaluating water resource infiltrations across the arid southwest, and for that matter, all of the arid U.S.

Next slide. Now, I come into the mountain. That infiltration now can flow down through that 300 meters. We've devoted a significant amount of total effort to understanding how water moved through the unsaturated zone. Those of you who go see the ESF, the exploratory studies facility, and the test alcoves and niches off of that, a large fraction of that testing was to evaluate water movement through the fractured porous rock that exists in there, the Topopah welded and non-welded rocks, and whether it's lithophysae or non-lithophysae rock types.

These then result, though, in essentially a series of flow fields, you know, how much water is moving through the rock mass, generally gravity driven. There is some lateral diversion, but a fairly small amount, especially at the higher climate states, et cetera. So, a significant amount of effort, a lot of this work, I'll try to, when I do this, point out some of the differences and some of the key players, as well. This is work done by Berkeley. By the way, I'm just standing up here as a mouthpiece, because everybody else is too busy working on the license application, so there's a ton of work and people behind this whole endeavor.

Next slide. Okay, the climate has been broken up into three climate states for the next 10,000 years. Present day, monsoon, it's a climate term, it's not your normal English definition of the word monsoon, and glacial transition. Monsoon, it's higher precipitation and a little bit higher temperature. Glacial transition is higher precipitation and a little bit cooler temperature. These have to be then propagated and factored into the assessment.

Onto the next slide. Okay, infiltration, I think I've talked about some of these processes that affect the net infiltration into the mountain.

Next slide. Okay, we end up ultimately with a series of maps, is probably the best way of describing them, describing infiltration rates at the surface and their time variation and uncertainty, the percolation flux, as it's called, at the repository horizon and its time variation and uncertainty, and, finally, the flux, water flux that may occur at the water table. So, all of these are just getting bulk water flow through the fractured rock mass.

In addition to the three climate states, there's high, medium and low, if you will, map associated with what we expect to be infiltration and percolation, a lower bound, and an upper bound. And, I use the word bound there somewhat loosely. A reasonably expected lower value and a reasonably expected higher value. based on observations and extrapolation.

Okay, next slide. If we keep going two at a time, we'll really move through here. I think we have this right, so I'm still on that first part where now I'm looking at the changes in the hydrology that result as a result of placing the waste in the mountain. Now, I have thermally driven processes that I have to consider. Those thermally driven processes affect water movement in the rock. They also affect water and vapor movement in the drift as a function of time.

The other thing now that I have is an underground opening. I can have the possibility for that water that was percolating in the rock to seep, where seep now is water that can get out of the rock and drip, if you will, into the emplacement drifts.

The seepage information, the seepage model has been developed also at Berkeley, based on a wide range of tests, niche tests, cross-hole tests, cross-drift tests, underground and from the surface to the alcoves, to evaluate the possibility of seepage. Most of these, there's no directly observed seepage under current ambient day percolation flux regime, so, we overstress the rock in order to induce seepage and evaluate (a) what's the threshold force water would likely seep, because I'm going to propagate this thing out to time, remember, with climate changes and percolation flux changes. So, we have models that describe the likelihood of seepage and the amount of seepage as a function of rock type, and as a function of distribution around the repository block.

Next slide. I think it's going to be a condensation. In addition, I think the Board is aware that in the ECRB, the enhanced characterization of the repository block area, whenever we shut that off, there is observed liquid moisture behind the non-ventilated portions of the drift. Although the chemical signature of those waters do not indicate seepage type water, so, again, no direct observation of any seepage, they are very probably condensate type water. And, so, the movement of vapor within the repository block due to heating, there will be different areas of the repository that are warmer than others, and other parts of the repository that will be cooler than others, and moisture will move, even under ambient, without forced ventilation, moisture will move due to those thermal gradients. So, there is a condensation model that evaluates the possibility and the redistribution of moisture in the drift.

Next slide. This just shows some of the processes affecting seepage. It's affected by the degradation characteristics of the rock, by the capillarity of the rock mass, by the amount of water that's moved through there. It's also affected by heat, which we'll come back to in a second.

Next slide. This is a slide that was used at the Board meeting in May. The upper left-hand part is essentially the seepage abstraction that drives the probability of the seepage percentage as a function of the three main variables that affected the capillarity of the rock, the permeability of the rock, and the amount of water moving through the rock. What you see here is variations, this didn't print out very well in the lower left-hand corner, but hopefully it's clear on your slides, variations with time as a result of the thermal heat that's applied. The right-hand one is just showing time variation of when the drift wall drops below boiling, and it's variable across the repository block because of the differing heat outputs and the edge effects of the repository itself. Those P numbers are the order in which the repository would be constructed.

Next slide. Now, we're going to go onto a little bit more into thermal hydrology. The thermal aspects are significant. They do affect the moisture movement both in the drift and in the rock. It is a process that, therefore, has to be evaluated.

Next slide. Thermal hydrologic model, those of you who are going underground on Tuesday or Wednesday, or whenever, you'll see the drift scale test. The drift scale test is the largest test of its kind anywhere in the world by an order of magnitude, roughly. It's had four years of heating and then it's now on its second plus year of cool down, where it was heated well above what we think will be repository type temperatures, and now it's cooling down.

The drift scale test has been used extensively to support the models used to evaluate thermal hydrologic behavior, thermal chemical behavior, a little bit for thermal mechanical behavior, but mostly the first two, thermal hydrologic and thermal chemical behavior, following the emplacement of heat producing waste. That thermal hydrologic environment affects the temperatures, it affects humidity, it affects saturation, it affects fluxes, it affects a lot of things down gradient from it, if you will, or downstream from it.

Next slide. Okay, this is just conceptually what's going on with respect to the heating of the rock mass, and the redistribution of moisture in the rock mass. First off, in the rock, we don't really show too much in this conceptual drawing, the condensation type effects and the axial type transport of vapor phase that will occur due to the differential temperatures of the different packages.

I should have pointed out when I was talking about the waste forms that the commercial spent nuclear fuel packages are quite warm. They produce quite a lot of energy still. The glass waste forms, the DOE spent nuclear fuel waste forms, and the Navy waste forms essentially create almost no energy. There's a little bit, but there's no residual energy that they're creating in heat and, therefore, temperature effects. So, the fact that we have different packages means we have different temperatures. And, evaluating the differences in the temperatures, we'll come back--I'm not sure whether I put a slide in here on that or not. I think I did.

Next slide. It might even be the next slide. Okay, here's some of the processes going on looking at it as if it were a 2-D section. Clearly, the drifts are much further apart than that. This is five and a half meters, and the drifts are 81 meters apart, you know, this is done for artistic reasons, not for true to scale reasons.

Next slide. Okay, this is another figure we used in May. It evaluates, the gray bars indicate the range of thermal hydrologic response of temperature, humidity, I think I have package temperature on the bottom, drift wall temperature at the top, and humidity in the drift, in the middle. As we pointed out in May, the humidity characteristics, the temperature characteristics do affect things like the likelihood of salt deliquescing, and the types of salt that could deliquesce on the package surface. It also affects the evaporative concentration of any water that might seep, because they will, once water, if water did seep into the drift, it would have some kind of evaporative profile that the humidity and temperature would be driving, that affect the chemistry of that water.

Next one. So, all of this integration is occurring within the TSPA.

Okay, I'm now into physical chemical environment. In addition to the thermal hydrologic changes, there's thermal chemical changes of the moisture in the rock, and as it comes into the drift and propagates that change in chemistry within the drift. The change in chemistry is fairly significant because it can affect the degradation characteristics of the engineered materials that are in the drift, like the drip shield and the waste package. So, understanding how the chemistry evolves is an important aspect of performance assessment.

What we see here is some of the major inputs to that thermal chemical evaluation. It also relies fairly heavily on the drift scale test, and our understanding of the drift scale test, but there are other natural analogues of thermal evolution, such as geothermal type systems and geyser type evaluations, even though they're much higher temperatures than what we're dealing with. And, these same models that we have for our evolution of chemistry have been used for evaluation of geysers and geothermal reservoir production.

Next slide. Oh, I was going to talk about the changes, wasn't I. I should probably try to catch up on the things that have changed a little bit. On the thermal hydrology aspects, the thing that's changed is condensation, so condensation effects are being included now. They were excluded, if you will, in the site recommendation analyses.

The thermal chemical work that we're in right now, there were thermal chemical evaluations in the site recommendation analyses, but we've taken those to the next stage, where the chemistry changes in the rock, and those chemistry changes in the rock and how they're propagated in the TSPA is a little bit different for the license application, performance assessment.

Once it gets into the drift, the evaporative profiles for the different geochemical signatures are different than they were in the SR. There's a new model, the precipitant salts model, which evaluates how incoming brine or aqueous phase, it's fairly dilute in the rock, but when it comes into the drift, it can become more of a brine. And, extension of those two, much higher temperatures has been included in the license application models.

This is just a general picture of the design elements. Let's go onto the next slide.

This is another slide that we presented to the Board in May. I was talking about the range of chemistries and also, you know, a schematic of what kind of fluxes we're talking about volumetric fluxes we're talking about, when the water potentially seeps into the drift, and then is subsequently evaporated down to the brine, because that water will, over a fairly long period of time, evaporate and leave behind a higher brine concentration.

We use five initial water chemistries shown in the upper left-hand, to propagate some aspects of the uncertainty of the initial water chemistry. And, you can see kind of a range of chloride and nitrate concentrations, which vary with time.

Next slide. Okay, now we're going to go into the drip shield and package. Starting with the drip shield, the drip shield is made of titanium. I don't know if Rick went into the details of the design associated with the drip shield or package. But, it has, you know, we've tested the titanium in a range of chemical thermal environments, as well as stress tested the titanium for the drip shield to evaluate the possibility of stress cracking of the titanium.

Next slide.

LATANISION: I'm sorry. Latanision, Board. What was your comment on the stress cracking?

ANDREWS: Your comment on Rick, or--

LATANISION: I'm sorry. Latanision, Board.

You said two magic words in there that immediately triggered--you were talking about the drip shield and stress cracking. I didn't catch your comment, however.

ANDREWS: We have some information data on the propagation, well, first off, the initiation of stress cracks in titanium, the effects of hydriding or other embrittlement processes on the likelihood of stress cracking of the drip shield, and those, you know, degradation modes, if you will, for the drip shield are included in the models, or the evaluation of those degradation modes of the drip shield. stress cracking of the drip shield.

LATANISION: Right. Latanision, Board.

I mean, it's a given that this stuff will stress corrosion crack. So, what is the attitude about why not replace it, and why use it, given all that?

ANDREWS: Well, it's in the design right now. I'm analyzing that interesting suggestion. Maybe--you probably should have asked Rick this morning on the design.

LATANISION: Latanision, Board.

Actually, I did.

ANDREWS: Oh, okay.

LATANISION: I think he referred it to you, but I'm not sure. I'm quite serious. I mean, this has been a question for a long time in terms of the Board's concern. We know this material is susceptible to stress corrosion cracking. We've known that for a long time. We've raised the issue. It's been talked about, but it's still in the model and design. And, I'm just curious about what the intention is in terms of handling it.

ANDREWS: Handling of it?

LATANISION: The fact that it is known to stress corrosion crack, how are we handling that in the model?

ANDREWS: Well, the fact that it cracks, you know, is well known, but then you have the issue of the morphology of the cracks and the propagation of the cracks and the distribution of the cracks, and what happens when water can come into contact with those cracks, all of which then have to be assessed with respect to the potential significance of that crack, if you will, with respect to performance.

LATANISION: I don't want to belabor this right now, but I mean, it would seem to me an obvious choice would be to replace it. And, I have not yet heard an explanation from anyone I've asked as to why that's not a consideration that's being given more attention.

ANDREWS: You know, I won't speak for DOE, but I do think they have the things that we presented to the Board, you know, the science and technology program, and one aspect of their looking at it is, if you will, alternative possible design features, or design things, you know, that are not in the reference design, not in the license application design. To evaluate, is there, you know, a cost savings, is there some other savings that might result from such a possible change. So, the license application design though has these drip shield out of titanium.

Okay, the waste package degradation, we spent some time in May talking about some of the data behind the models that support the evaluation of some of the degradation modes of the package. We're kind of focused on localized corrosion, and general corrosion. There are similar information for stress corrosion cracking, and other degradation modes, potential degradation modes for the Alloy 22.

One difference from the license application analyses from the SR is the low likelihood of localized corrosion will probably be in that analysis, and the potential consequences and risks associated with that low likelihood will be addressed.

Next slide. This is the conceptual picture.

Next slide. These are some of the data that Dr. Payer I think presented to the Board in May, showing the very low corrosion rates at even very high temperatures, and the corrosion resistance of Alloy 22 amongst a family of other alloys in a very, very aggressive and extremely unlikely environment at Yucca Mountain.

Next slide. Okay, now we're going to look at inside the package. What I tried to do is kind of walk through from the surface down through the natural parts, now into the engineered parts, and actually now into the package. So, of course, I never get to this part of the presentation, or system analysis, unless something has happened to the package to degrade the package either from a crack or from a localized corrosion, crevice corrosion pit, or from any other degradation mode, no matter what the initiating cause might have been. But, once I get inside the package, now I have zircaloy considerations, and I think Dr. Howard asked about the zircaloy information, and the waste form degradation information itself.

The waste form, the zircaloy information is, as I said earlier, is generally literature type information of zircaloy behavior, most of that generated from reactor type experience and testing. With respect to the waste forms, in particular for the commercial spent nuclear fuel waste forms and the high-level waste glass waste forms, the evaluation of degradation characteristics, alteration characteristics, in an oxidizing type environment, remember I'm above the water table, so I have generally enough oxygen around to have oxygen type reactions, oxygen driven reactions occurring if the waste form is exposed.

So, those oxitive type processes and alteration processes on the waste form have been generally derived from laboratory testing, most of it at Argonne and Pacific Northwest National Labs. We looked at the degradation characteristics of commercial spent nuclear fuel under likely Yucca Mountain conditions, including human error conditions and low dripping possible conditions. So, we utilized those alteration models derived from those data and tests that have been performed at Argonne and PNL.

There is a bit of a comparison to some natural analogues. For example, at Pena Blanca in Mexico, which the center, the Southwest Research Institute have been evaluating, and we've been corroborating that with our own analyses of Pena Blanca samples to evaluate the degradation characteristics of, in this case, a uranium type deposit in an oxidizing environment.

There's other aspects going on in here that are important. One of those is the solubility of the radionuclides. Given I have a aqueous phase and I have an aqueous phase potentially present on the surface of the waste form, and the waste form has altered, and altered to different uranium phases, there is a possibility that radionuclides were released into that aqueous phase. And, then, there is an evaluation of how soluble are those radionuclides in that aqueous phase.

And, there, we have literature and laboratory data ourselves, as well as the international community. I mean, this is of interest, of course, to a lot of people for a lot of different reasons, not the least of which is radioactive waste disposal. So, we used those laboratory data in relevant environments to evaluate the solubility of key radionuclides.

Also, in here, is the potential for radionuclides once they come out into that aqueous phase to sorb onto colloids of different types, and those colloids can be, given the right set of circumstances, more mobile than dissolved constituents of that same radionuclide. So, for example, things like plutonium, americium, are or can be transported in a colloidal phase rather than just simply a dissolved constituent. So, that's also, first evaluated here, it's going to be reevaluated when I get into the drift, because the chemistry is different in the package than it is in the drift.

So, I have this base time variation of chemistry, which has a time variation of solubility, and a time variation of colloid stability and migration.

Go onto the next slide. This is just a schematic of different scales of things going on inside the package. I start with the assembly, or scale of the meter, if you will, or tens of centimeters, down to an individual clad, you know, a scale of a centimeter, and down to an individual pellet of an individual rod, down at the millimeter type scale. And, it's this, you know, oxidation and alteration of the waste form itself that is the starting point, if you will, for the potential release of radionuclides into a mobile phase, given that, you know, my package has developed some kind of a breach in it.

Next slide. Now, I'm still coming around the wheel, and now I'm getting things out of the package, so I have what we've called engineered barrier system flow and transport. It's affected by the moisture inside the package. It's affected by the degradation characteristics of the package. It's affected by the chemistry inside the package, which varies with time, as I mentioned earlier, and the type of waste that exists.

Let's go onto the next side. There's not much to say about the EBS flow itself. EBS transport, now it depends on the type of release mechanism that I have, and different radionuclides will behave differently for different release mechanisms. One would be a diffusive type release mechanism if there's no advectively moving water, so the water is not dripping through the package, it's just condensed in the package, and through thin film, radionuclides could potentially diffuse through that thin film. Or, if there's a hole in the package, it could advect, you know, through the package and radionuclides could be released via advection.

This is one area where there's significant uncertainty associated with the continuity and extension of any film. Imagine I have a package that degraded after some end years, or end thousand years, and now I have the potential anyway for moisture to condense somewhere inside the package, either hydroscopically or otherwise. Now, of course, the inside of the package, especially for commercial fuel, is always warmer than the side of the package, which is warmer still than the drift wall. So, logic would be the moisture would prefer, if it's going to condense anywhere, or going to be absorbed anywhere, prefer to do that on the drift wall near the cooler packages, not on the hottest waste form, which is the commercial spent nuclear fuel.

However, it is possible, and there's some information of hydroscopic water and, you know, is that water thick enough to have radionuclides diffuse through. Well, there's some uncertainty associated with that. I think the Board has had a dissenting opinion in one of their letters to us that was written by the previous Board Chairman about that particular aspect of what does it really look like when moisture is inside the package, and how conservative is the

Department of Energy being with respect to the assumption that that moisture is a continuous moisture film.

The International Peer Review raised the same question, you know, I think their words were a little stronger in fact than the previous Board Chairman. The truth of the matter is that it is very uncertain. The likelihood of there being an interconnected film of moisture on the waste form that's nicely continuous through the waste form and into the cracks in the package or holes in the package back into the invert is very unlikely, but there's not very much information to exclude it. So, it is included right now as a potential transport pathway through the engineered barrier system. It might be one of those areas, going back to Leon's question, where an expert elicitation may, you know, have done something different. But, the conservatism and trying to quantify the range of possible diffusion characteristics has been, and the uncertainty associated with that, has been included in the Total System Performance Assessment.

Let's go onto the next one. By the way, that's the same as what was done in the SR. Now we're talking about transport through the drift.

Next slide. I got the radionuclides out of the package into the drift, and--oh, I guess I got them through the drift fairly quickly, too. So, now I'm into the unsaturated zone. Now, I have a release either into the fractures or into the matrix at that drift wall unsaturated zone contact, and they can be transported through advective diffusive disbursive processes in the unsaturated zone. There, we have some indirect observations of transport, for example, radiotracers, such as carbon 14 and others. We have some direct testing of transport at Busted Butte. I think that was presented to the Board in April to confirm the model. And, that's the basis for the transport through the unsaturated zone by aqueous pathways.

Next slide. That's the conceptual picture of the transport. It is different for the welded and nonwelded units. The nonwelded units are matrix driven predominantly. The welded units are fracture driven transport predominantly.

Next slide. Now we're in the saturated zone.

Next slide. Saturated zone has been fairly extensively evaluated by the survey, Sandia, Los Alamos. We have two large scale--well, no, really one large scale test in the fractured tuff. We've always had plans to do an alluvial, a large scale alluvial test. I think Nye County has been doing a lot of that, and reported on their progress to the Board last time in April. Maybe that wasn't a full Board meeting. That might have been just a natural system meeting. I forget. So, there is a number of direct observations of flow paths, you know, inferred flow paths, I should say, from geochemistry, from hydraulics, et cetera.

Next slide. This is the same as what you had in when I was talking about the barrier really, some of the processes going on within the saturated zone that are accommodated within the model.

Next slide. This is a cartoon--well, it's not really a cartoon, it's the actual flow paths calculated from the saturated zone flow model, going from the repository, beneath the repository, to the southeast, and then to the south, southwest, essentially following the trace of Forty Mile Wash.

NELSON: Nelson, Board.

Can you point out where the site is. Because I'm not sure that everybody knows that picture.

ANDREWS: Okay. The repository is up here, essentially. And, what we've done in this model, this is now at the scale, this is about 30 kilometers north to south through this model, about 14 kilometers east to west. And, what we've done is just put, essentially numerically put tracers at the top of the water table, and then just traced where those tracers would most likely go for the expected flow system that we expect to be out there. There's uncertainty in that flow system that I talked about earlier, but this is more or less the expected flow system.

The 18 kilometer point is essentially going--well, it's a little further south than that--about through there. So, that's the 18 kilometer fence line for doing the evaluation of groundwater concentrations and doses. And, this is going to give me essentially a mass flux crossing that boundary.

If you remember back to the requirements part, we don't really have to worry about concentrations per se because that mass flux is going to be put into the representative volume for the purposes of groundwater concentration purposes, and that representative volume, which is 3,000 acre feet per year, is the same representative volume to be used for individual protection. So, it's a mass flux or activity flux, divided by a volumetric flux, gives me a concentration.

Next slide. Now we come to the biosphere.

Next slide. The biosphere, there was a regional survey done of eating habits, employment habits, et cetera, done in '98, I think, the time frame of the Amargosa Valley area. That regional information has been used to describe the characteristics of the reasonably maximally exposed individual, especially those characteristics that weren't directly specified by the regulation like he or she drinks two liters per day of groundwater.

That's been supplemented by other information from

EPA and site surveys done, census type surveys, to describe the characteristics of that reasonably maximally exposed individual.

Next slide. These are some of the pathways that are considered in the biosphere model. Ultimately, what the biosphere model does to the Total System Performance Assessment is it gives essentially a dose conversion factor, takes concentration, converts it to dose.

Next slide. Okay, now we're going to go, those first ones were all related to what we call the nominal scenario class, kind of what you would expect how the repository will behave over time. Now I have two possible disruptive events, an igneous disruptive event and a seismic disruptive event. Start with igneous. Let's go onto the next slide.

The igneous has two possible occurrences. One, it can have an eruption, and take waste with it in an ash, kind of, if you will, or distribution of solid particles that are then potentially blown to the south, or wherever they might be blown to, and, therefore, potentially affect the concentration of radionuclides that the maximally exposed individual might receive. Or, as in this case, it could be an intrusive type event. The event occurred, hit the repository, magma filled the repository drifts, and then all the subsequent effects occurred, degradation of the package, degradation of the waste form, degradation of the drip shield, change in chemistry associated with the event occurring, et cetera, et cetera.

This one was amenable, at least the initiation part of this, to expert elicitation, results of which are shown in the next slide, I think. No, this is just a conceptual picture. And, this is that distribution. So, this is that distribution. As you can see, the mean of this distribution is slightly larger than one times 10^{-8}. Therefore, it's included. It's unlikely, but included. Therefore, the consequences need to be assessed, and the risk associated with the event need to be evaluated and included in the assessment of individual protection.

Also, it does not meet the criteria of likely. Therefore, it does not have to be considered in the evaluation of groundwater protection. So, here's an event where how it's treated with respect to likely versus unlikely makes a difference.

Next slide. Now we have the eruptive case. Let's keep going on this one. Next one? Again, it uses that same probability distribution, and then now, based on energy and volumes and rates, all of which are uncertain, it can eject a certain fraction of the repository to the surface, and wind can blow it towards the reasonably maximally exposed individual, or wherever the wind is blowing at that particular time when that event occurs, all of which are uncertain.

So, let's go to the next one. This is just a little schematic, you know, of the wind happening to blow south in this particular case. And, now I have a different biosphere. So, the biosphere characteristics in the case of an eruptive, following an eruptive event, and the possible inhalation following that eruptive event, are considered, in addition to the aqueous type pathways that all the ones up to this time have considered.

Next. Now, we have seismic. John talked a little bit about this this morning with respect to the initiating event part of seismic. But, given that initiating event occurred, and a certain velocity and acceleration occurred with that initiating event, the subsequent effects and consequences and ultimately risks associated with that initiating event are now propagated into the Total System Performance Assessment.

The types of effects that can occur are mechanical shaking, mechanical degradation associated with the drip shield, with the package, with the cladding, due to the vibratory ground motion that occurs for whatever the annual exceedence frequency might have been for that particular I'll use the word scenario, not scenario, class.

83, John? So, there's a series of calculations done for range of different peak ground velocities, a range of different accelerations, essentially a range of different synthetic time histories of velocities and amplitudes as a function of the initiating event.

Next slide. This just shows schematically some of the things that can happen after the seismic event. One of the other things that can happen after a seismic event of sufficient peak ground velocity acceleration is fairly complete degradation of the mechanical properties in and around the drift. So, you can have the likelihood of significant drift degradation, drift collapse following a large seismic event. And, those degradations have been factored into the system analysis. Once it collapses, of course, my environment changes, my thermal environment changes, my hydrologic environment changes, and those changes are also factored into the system assessment.

This is different from the site recommendation. At the site recommendation, these low probability seismic events were considered to not have any effect, and, therefore, no consequence, and, therefore, no risk. The revised analyses for the high peak ground velocities that were available last summer, summer of '03, fall of '03 time frame lead to some degradation of the package, and of the drip shield and of the cladding at those peak ground velocities and accelerations.

We've, as John pointed out, done a revision of what we think are the most reasonable range of peak ground velocities, and that range of peak ground velocities are now factored into the analysis. But, it's not a zero effect, it is a minor effect, unlikely though it may be, that needs to be propagated through the performance assessment.

Next slide.

ABKOWITZ: Bob, you can take a little bit more time with these last three.

ANDREWS: Okay. Okay, some of these I didn't hit, I must admit. These next two are the model changes within the processes and features and events that feed the TSPA. And, even when I put the word major change here, there are some, you know, minor changes in some of these things, not significant, but there can be some minor changes.

With respect to seepage, there was not a model in the lower lith for the SR. There is an explicit model and uncertainty treatment in the lower lith for the--actually, it's the lith, period, whether it's upper or lower lith. There's a lot of comment on the flow focusing factor in the SR. We still use a flow focusing factor, but that factor, which is kind of a scale issue going from the tens of meters of scale down to the meters of scale at the drift, where you haven't factored in the heterogeneity of the rock mass at that tens of meters into your model, so they've done a re-analysis of this, and that scale effect, if you will, of where might water be channelized, or where might water flow at a scale of meters, has been factored into the seepage abstraction and the seepage model itself.

We've talked a little bit about drift collapse following a seismic event. That's explicitly included now. And, the thermal effects of a vaporization barrier right at the drift wall, an issue I think we discussed with the Board in May, although it was not included in the SR, is included in the TSPA for the license application.

With respect to thermal hydrology, there is a range of calcs that have been performed over a range of different thermal conductivities and percolation fluxes, to try to accommodate the fact that the thermal conductivity might be lower, might be higher, and the percolation flux might be lower, might be higher. So, a range of thermal hydrologic responses to capture the full range, if you will, of likely thermal hydrologic behavior has been conducted.

I mentioned earlier the condensation effects are being included. All of the models that use the drift scale test as the basis for their validation could now use, for the license application, could now use at least one year of cool down. Some of them use a little bit more than one year of cool down data from those responses. At the time of the SR, we were still in the heat-up phase of the four years. I think we just turned it off two years now. So, they relied on those additional data from the cool down portion of the drift scale test. That's the DST there is drift scale test, for support of the model validity.

The early footprint did change a little bit, so incorporating that revised footprint, it's kind of the same area, but its configuration is a little different, was incorporated in any model that relied on or needed information with respect to the footprint.

Going down to the thermal chemistry, we explicitly propagated the uncertainty in the initial pore water chemistry, those pore water chemistries that I briefly mentioned, and we talked about at some length in May. There was a slightly revised approach for how we propagate the thermal chemical evolution in the rock. We went away from the quote, unquote high saturation zone to the quote, unquote front zone, even though that front zone nearest the drifts has a very small volume of water associated with it.

The thermal hydrologic response uncertainty is propagated through the thermal chemistry response uncertainty, and the possibility, albeit unlikely, but the possibility of there being deliquescent salts in the dusts that form on the package has been included in the thermal chemical evolution and, therefore, in the TSPA itself.

The cementitious materials was a relative minor effect. There are still cementitious materials on the turnouts and in the access mains, but not any in the emplacement drifts themselves. And, in fact, the ground support system is a little different. I don't know if I have that on here. We use these Bernald sheets now instead of rock bolts for ground support.

The waste package corrosion stuff, there's now the five year data on the weight loss information from Livermore. At the time of the SR, I think we only had the two and a half year data pulled from that. We talked at good length in May about the localized corrosion initiation as a function of principally temperature, pH, nitrate, chloride, and nitrate/chloride ratios, which are those corrosion potential and critical potential data that Dr. Payer presented in May.

The stress calcs, because of the change in stress mitigation technique for the outer lid to a laser peening stress mitigation technique, the stress calcs were redone so there's revised stresses on the welds. There's a slightly revised treatment of weld flaw, and there's additional data on the threshold stress intensity factor and the uncertainty on the threshold stress intensity factor.

The in-package chemistry models have changed, depending on the amount of water that may get into the package. So, they've kind of considered the chemistry associated with a vapor type hydration chemistry, or as a liquid. This is a fairly complex, you know, problem of water, waste form degradation characteristic. So, we've propagated the uncertainty associated with that characterization forward into the system model.

The colloids fractions have been revised, and we've re-evaluated, as I said earlier, some of the solubility models associated with, in particular, neptunium, plutonium, americium, solubilities based on uncertainty characterization of some of the thermodynamic data that are the fundamental underpinnings of some of those solubility evaluations.

Next slide. Okay, the fact that there's degraded package materials and basket materials sitting there, and those degraded materials do affect the transport, has been factored into the TSPA.

The UZ transport didn't change too much. There is a slightly revised matrix diffusion model in the piece of software that's used for UZ transport.

There's no major changes in saturated zone transport. You know, I'm looking at this from a TSPA perspective. There are differences in the characterization of uncertainty for where is the tuff/alluvium contact, and where is the anisotropy in the tuffaceous rock units, but in terms of net effect on system response, it's fairly insignificant.

Biosphere now has an explicit, it did before, but revised the eruptive biosphere dose conversion factor.

Now, in igneous and seismic. Well, you can read them here. Let's see, after the igneous intrusive event, we still assume that there's no more barrier function of the drip shield, the waste package, the cladding, that the 1200 degree C-ish intrusive event is sufficient to provide no more barrier function of the package or drip shield. I think you're going to see some--well, maybe you're not. ACNW is going to see some results of some other work from EPRI that kind of questions the conservatism of that particular assumption, tomorrow, or Wednesday, or sometime.

There's a revised wind distribution updated NOAH information used in the ash redistribution, in particular, wind velocities at higher elevations, which is where the, you know, like at 20,000 feet, 30,000 feet, which is where the eruptive material may go.

There's been an ash redistribution following event. That is in the SR, we thought we were reasonably conservative by always having the wind blow south and hit the reasonably maximally exposed individual. NRC questioned that conservatism, so essentially said what about geomorphic processes that could redistribute this ash once it's deposited. So, we developed a, did some testing, some observations, field observations in Forty Mile Wash, and developed a model of potential, essentially a geomorphic model, if you will, of potential ash redistribution following an event. So, that redistribution possibility and model and parameters is in the TSPA.

We talked about inhalation dose changing a little bit. And, the backfill, I think in the SR, I can't remember actually, but I'm not sure if there was backfill between the drifts in the access main. There is backfill explicitly now in the access mains between drifts, and that has been included in the effects of any potential magma interaction between the drifts, or gas migration between drifts.

In the seismic, John talked about some of these things this morning with respect to initiating event, and all the potential downstream effects following an event, like drift collapse and thermal effects of a drift collapse, and changes in seepage due to a drift collapse have been incorporated in the model.

Next slide. So, in conclusion, and I apologize for this table, because I had to kind of turn it this way. You know, we have looked at this model for the last 15 years. We're now at the stage of having, we think, adequately incorporated all of relevant features, events and processes, the uncertainty in those features, events and processes, propagate that uncertainty through to develop a distribution, because there is a distribution. There are a large number of I'll use the word scenarios, I would have called them realizations rather than scenarios, but maybe there's a lingo here between PRA and TSPA, to evaluate the potential consequences and risks associated with initiating events and nominal or expected behavior.

All of these models, even though I haven't discussed them in any detail, but we've had separate discussions on many of these model areas with this Board, with ACNW. They're based on either direct test data, such as ESF type data, or mountain type data, or they're based on laboratory data, or you use analogues to support them, or to look at alternatives that other people may have come up with, whether they be our own alternatives, or whether they be EPRI's, or NRC's, or whoever's, alternative models associated with a particular process to evaluate the need to either include that alternative model or exclude that alternative model, because it either doesn't match observations, or its inclusion would demonstrably lower the dose, i.e. we're on the conservative side, if you will.

We've used the TSPA for a lot of different purposes. It is true, the final purpose is to support the license application, but it also has another purpose, in addition to the compliance purpose, that is in the license application, but it's a forward pointer to the performance confirmation requirements of the license application, which I haven't put up here as a requirement, but it is an explicit requirement, and the bases for the performance confirmation program is in large part based on the TSPA model and uncertainty associated with that.

And, with that, I think I'll stop, Mark.

ABKOWITZ: Okay, thank you, Bob. First of all, that was well organized and very helpful, and no pun intended, you presented us with a mountain of information to digest.

We're going to open it up here for questions in just a moment, and I'd like to ask Board members if they could just sort of reserve their questions for the one dying question they really want to ask, and try not to carry it beyond that because of the time situation.

I'm going to lead things off with my one question. John Arthur this morning presented the TSPA modeling process as being in the red zone, and was quick to add that that didn't mean that it was a poor performer, but that it was kind of on the critical path. And, I think that we've certainly developed an appreciation for just the complexity of trying to model a system like this, and the way that the modeling process has evolved. But, my question really kind of focuses on the idea that you've got several different modeling components that are being developed in various places, and somehow they have to integrate now, and it's this sort of the classic opportunity for the left-hand/right-hand problem. How much of that are you having to deal with right now in terms of the outputs coming from one place, being able to marry up to the way the inputs are needed in the next place?

ANDREWS: That's a good question. You can have that, and, in fact, modeler A in process X, and I'm going to give you a good example of this, and it also relates to an example we talked about in the May meeting. Model X might be reasonable or conservative or complex and had to simplify in a certain way that's different than model Y, with very related processes, but not overlapping processes. So, such inconsistencies, if you will, can evolve as a result of that.

And, then we have to evaluate those inconsistencies, first off, and those inconsistencies, you're right, really only manifest themselves with respect to does it make a difference or not when you get to a complete integration, which is at this final stage, this Total System Performance Assessment stage, because that inconsistency either may not have been evident, or might have been okay, you know, at the individual process level.

So, it is then incumbent on the TSPA, and there's two places where we've done this within the TSPA, one is the independent review that's been performed of the TSPA has identified some of these as part of their review. When they reviewed it, they started with the TSPA, but they quickly pulled the strings into, you know, the myriads of feeds into the TSPA, and identified, you know, potential inconsistencies that need to be then evaluated. By the way, the YMRP also has a requirement to evaluate these potential inconsistencies when you have complex models. And, they do exist. Some of them do exist.

One example I think we brought up to the Board in May, and I think it's probably worthwhile bringing it up here, is with respect to the thermal hydrologic evolution, we have a wide range of in-drift thermal hydrologic responses, in part reflecting hot packages, cold packages, different rock types, different thermal conductivities, different locations around the repository block, the goal being to have a full range of possible thermal hydrologic responses.

When we came to doing thermal chemistry in the rock, the thermal chemistry model in the rock is an incredibly computationally intensive model. So, the approach taken was take a representative location with a representative rock type with a representative thermal profile and a representative thermal conductivity, and propagate what we think is the most significant uncertainty, which is the initial water chemistry, and propagate that uncertainty, but not propagate all the variability associated with the wide range of thermal hydrologic responses.

So, there is, if you will, a potential inconsistency between the thermal chemistry, i.e. chemistry evolution in the rock, and the thermal hydrology in the drift, and within the TSPA, you're marrying up those two things to evaluate, well, does this make any difference. And, in fact, it doesn't make too much difference because you've over predicted the chemical response at any particular time, in terms of its potential degradation characteristics.

So, you know, had we been able to do thousands of thermal chemistry evaluations, we would have abstracted this a little bit differently. But, we simplified it. And, we have to be mindful, you're right, of those inconsistencies and document them and discuss what they mean and why they're inconsistent and what significance it has.

ABKOWITZ: I've got Daryle, then John, and then George, and then Thure and then Ali. Daryle?

BUSCH: The Board, I must say, that was an excellent presentation for the new members of the Board. The insightfulness into the modeler's way that these very different contributions are made to the total decompensation process of this monument we wish to build. I couldn't help but feeling, and of course that's something that you probably want too, and that is there must be a way that you can give us a scaled figure for each of those steps. You must have one in mind for your own purposes in the future. There has to be a limit, a probably and an improbable velocity for each of these kinds of processes to occur.

I think, for example, if you've got a stainless steel lining on that drift, it's not going to be there very long. And, so, that must be very short. Then, the next phase is there any way you could give us a simple guesstimate of what the scaling is for each of these different processes, or for some of them?

ANDREWS: Scaling with time now?

BUSCH: In time, exactly.

ANDREWS: Yes, I think some of what we tried to do in May, and I only grabbed a couple of the May presentations, where we talked about this is our expected thermal hydrologic response, our range of thermal chemistry responses, and what are the likely degradation modes focusing on localized corrosion, which was kind of the focus of the May meeting, focusing on localized corrosion, what are the dominant degradation modes and what do the data tell us at these different times, if you will, you know, intervals of time.

So, you can do that for two or three parts of the system. When you try to put the whole system together, it becomes a little bit unwieldy.

BUSCH: Well, aren't the scales very different for different components?

ANDREWS: Yes, they are.

BUSCH: How long does that drip shield last? How long does the cask, container last. I realize there's a great uncertainty with each of these, but some of those are not going to be real, real long, are they?

ANDREWS: Well, some of them are pretty long, within the 10,000 years--

BUSCH: These are the numbers I'd like to hear. I haven't heard them. I think you live with them and have some feeling for them, but I have not. Each of these steps, you're saying it's possible, you just can't do them for me right now, I think.

ANDREWS: Yes, that's right.

ABKOWITZ: John?

GARRICK: Garrick, Board.

I have one question and 25 corollaries. If you go to Slide 85 and 86, I'll ask a simple question, and you look at the changes, the principal changes that have been made, would you comment on which of those changes as having the greatest impact and in which direction?

ANDREWS: Impact on dose?

GARRICK: Impact on dose.

ANDREWS: Well, I think the ones on the next slide on seismic and igneous--

GARRICK: Let's look at the nominal case.

ANDREWS: Oh, on the nominal?

GARRICK: Yes, because I don't believe either of the other two.

ANDREWS: They are unlikely, you're right. But, go back to the previous one, John. On nominal, it's probably going to be one of these localized corrosion issues, I would guess, the biggest change.

GARRICK: And, in which direction?

ANDREWS: It's insignificant in comparison to the ones you didn't want to talk about, from a risk perspective. Does that answer your question?

GARRICK: Not very well. But, we'll leave it at that.

ANDREWS: I think it's not, you know, given how the early degradation of the package considered in the SR, in fact, it's about the same order, you know, it's not dramatically significant.

GARRICK: Okay.

ABKOWITZ: I think that's a to be continued. George?

HORNBERGER: Hornberger, Board.

So, I'll go to one then that you think does matter. You mentioned that the seismic dose was modest, okay? And, I know you're not presenting--

ANDREWS: Did I say modest?

HORNBERGER: You said modest. Minor maybe. Minor, you may have said. And, so, I guess my question is I know you're not presenting results, but can you sort of bracket it? Is it a millirem, a microrem, a nanorem, a pizmorem?

ANDREWS: You guys are tough. Significantly below the standard, I think, is--and you can define significantly.

ABKOWITZ: I'd like to that Thure Cerling is here, and not only that, he has a question to ask.

CERLING: Cerling, Board.

In Slide 57, you gave a more detailed description of the chemistry of the waste package failure, certainly much more detailed than I've ever seen before. And, in this current model, if we would look at the lifetime, what does this current model give for what fraction of the waste packages fail and what fraction is released and over what sort of time?

ANDREWS: It's a very small fraction of them are packages, and even smaller fraction of total inventory, in part because of some of these degradation characteristics that are inside the package.

CERLING: So, following on that, has your new modeling had the fraction that failed, is it going up or going down from the previous TSPA?

ANDREWS: It depends on the degradation mode. But, I'd say they're about the same, leaving aside the disruptive events, you know, for the time being, I mean like seismic and igneous disruptive events. So, the nominal degradation, I don't have the numbers here in front of me, but they're not dramatically dissimilar.

CERLING: Okay, thank you.

ABKOWITZ: Ali?

MOSLEH: First, I'd like to thank you. I appreciate the presentation you've made, and it's extremely important. I do have a question on the process you mentioned in response to questions earlier. One is to be mindful of the interface between submodels. So, as an issue, it's appreciated, it's understood. But, what I did not get, I'm not sure if you answered positively, whether you have actually done that, sweeping the model from left to right, addressing those potential internal inconsistencies, just kind of a natural thing, it's such a complex modeling process.

ANDREWS: Is it comprehensive? I think it's reasonably so. We've had a number of people look at it from left to right, and right to left, as you say. Whether or not they've identified every one, you know, I think we're still in the process of documenting this model as we speak, and they're identifying, oh, this little input here is inconsistent with this one for these following three reasons, does it make a difference, you know, in terms of the assumptions that were made in a particular process model, and how they get propagated through. So, it's still being developed. I think we have a fairly complete list of those, and are documenting it now.

MOSLEH: This is an integral part of your process?

ANDREWS: Yes.

MOSLEH: Okay.

ABKOWITZ: Dick, and then Dave, and then Howard.

PARIZEK: Parizek.

I have a question about how long does the model run? Is that fair to ask? Are you going to give us somewhere along the line 150,000 years, or 200,000 years?

ANDREWS: The analyses are being performed to 20,000 years.

PARIZEK: Okay. And, then, does the model also deal with this question of vapor movement in the unsaturated zone? I mean, all kinds of things are going on, obviously, in terms of what's happening from the heat and the chemistry, and so on. But, in terms of just how much moisture is moved because of this out of the mountain, this whole question of the ventilation I think--

ANDREWS: By the time it--some of the process models have evaluated moisture, you know, mass moisture redistribution, if you will, as a result of the thermal effects and the ambient effects, and where that moisture is redistributed to, and then it's, of course, included with the moisture over there. From the TSPA perspective, it's more dealing with flux rather than, you know, movements of mass, water mass. So, it's flux rates of radionuclides, flux rates of water. So, you know, where the water is, volumetrically, the mass, if you will, it's not so much of a consideration with respect to the TSPA.

PARIZEK: One other question. In terms of just the runs that you have made, then there's a question of new data, like the three layer model is part of the regional flow model, groundwater flow model, has input to the site scale model, but somewhere along the line, provisions are being made, is work being done on the interface, and assuming that, you know, several years from now, more of this is done, if this was to happen, is the program committed to do these things, is there another TSPA coming up that captures then revisions that all of that brings to bear?

You know, right now, I'm not sure where the certain things you've sort of ended with, or will have ended with, and still there's a lot of detail that's maybe not carried as far as it may still get carried. And, is that a closure of the license application?

ANDREWS: Well, yes, I think there's updates, you know, as necessary of the license application. And, once the review period has been completed, you know, all the results of the to date performance confirmation, and any other activities that may have affected or modified a particular model would then be factored into a TSPA at that particular time, which is some three years plus hence right now.

PARIZEK: Thank you.

ABKOWITZ: David?

DUQUETTE: Duquette, Board.

I hope I'm not paraphrasing, but I've heard minor, not very much, doesn't do very much, has the largest effect, but still doesn't do very much. What are we talking about? How big an effect is it in terms of either dose or to time of release of the regulatory dose?

ANDREWS: That's why, when I asked John to clarify his question, I said which do you want to talk about? Do you want to talk about risk and the magnitude of risk, i.e. dose, or do you want to break out the question into does it affect nominal behavior or not, because it can be a very different answer. One's an absolute one, and you're comparing to 15 millirems, and the other one is kind of a relative one. How much did it move that particular piece part, even if that one didn't affect your ability or didn't affect your probability weighted dose to the reasonably maximally exposed individual. So, the quote, unquote significance test can be different for those different comparisons. So, it's somewhat unfortunate that I can't show the plots, and then say, well, now you can see that this one is here and this one is here, and that's what I'm calling insignificant.

DUQUETTE: Duquette, Board.

I presume that you're going to share those with us at some point?

ANDREWS: Oh, I would guess so, yes, and with NRC and the public and everybody else.

ABKOWITZ: Howard?

ARNOLD: Arnold, Board.

My question obviously comes from ignorance of your model. But, I'm interested in the fine structure. At some point in time in the future, different parts of the repository will be behaving in different ways. Do you run the models separately for individual locations, or how do you account for this fine structure?

ANDREWS: It depends, you know, and the example I was using earlier on the thermal hydrologic one, there's five areas of the repository, and within each of those areas, there are different waste package type groupings, if you will. So, there's a spatial structure and a waste package to waste package structure on the distribution of thermal hydrologic responses. And, that structure, you know, is accommodated if there was any release from one of those five sub-areas, the release would go into the corresponding unsaturated zone flux at that five grouped location.

So, I haven't modelled every package. I've tried to model reasonably groups of packages and package types, trying to reflect the different packages have different thermal behavior, they have different inventories, they have different, you know--

ARNOLD: Different QA records?

ANDREWS: Yes, different QA records, and different characteristics when they're exposed. The DOE spent nuclear fuel, for example, we've taken essentially no credit for that waste form. It's assumed to alter as soon as the waste package has degraded to a point where oxygen can get in. But, for commercial spent nuclear fuel, it's very different, because you have the cladding and the degradation characteristics of the cladding.

So, we tried to put the things that we thought structurally, I don't mean rock structure, but structure from the model, make a difference, like different package types and different, generally different package locations, without trying to say we're modeling every single package, and every single location. So, there is a little bit of a spatial averaging, if you will, that's going on with respect to that discretization, which I didn't share with you today, but we certainly will.

ABKOWITZ: Priscilla, you have the last word.

NELSON: Thank you.

With reference to Slide 25, you've got this drift key way in there. Now, I don't know that I've really consciously ever seen a drawing that showed it like this, and it raises some questions. Since you don't expect any waste packages of any significant numbers to actually fail, the fact that it says limits the spread of radioactive hazards to the repository footprint, to me that sort of indicates that I interpret that, for example, the igneous activity is driving it. So, it screws up the possibility of ventilation and some other things along the way, so I'm wondering that's a pretty hefty response, with possible impacts elsewhere on the project to put these plugs in to respond to this event of unlikely occurrence. Do you have any comment on that?

ANDREWS: You know, if you were doing a risk/benefit, and if risk was driven by dose, not some other risk measure, you would do something like this, because if that event occurs, even though it's almost very unlikely, but not quite very unlikely, it can have significant consequences. And, this is one engineering feature whose, in order to reduce that hazard, i.e. risk, has been designed and is being analyzed in the license application.

ABKOWITZ: Thank you, Bob. We are going to shorten our break, and we'll reconvene in exactly ten minutes. Thank you.

(Whereupon, a brief recess was taken.)

ABKOWITZ: If I could ask people to take their seats?

I want to resume our schedule here, and I want to start by pointing out that during the break, the stakes have been raised. One of my colleagues came up to me and said that they're considering another new unit of measurement called the Abkowitz, which is how much behind schedule you can become on a routine basis. So, in an attempt to dissuade that effort, I think we need to press on.

I also wanted to acknowledge yet another former Board member who's been a private citizen for longer than the others that we've cited today, and that's Warner North. Warner, if you're in the room, if you could identify yourself? Okay. And, he is actually part of the original Board, the first group that was constituted, and I'm sure that there's all kinds of interesting stories that he can share with us. And, he's probably wondering that the more things change, the more they stay the same. But, we'll talk about that at another time.

We're going to move on now to--

NORTH: Thank you very much. I just offered to come by the Board dinner for a drink, but there isn't time. Let me just wish you all good luck and God speed.

ABKOWITZ: Thank you. Okay, we're going to move on now to another point of view with regard to performance assessment, and this is a presentation that Tim McCartin from the Nuclear Regulatory Commission will be making. The topic of his discussion is the criteria for NRC review of TSPA and also some related risk insights.

For those who don't know Tim, he's the Senior Advisor for the Performance Assessment in the Division of Waste Management Office of Nuclear Material Safety and Safeguards of the U.S. Nuclear Regulatory Commission. That's a mouthful. Is that all on your business card?

Over the past 20 years, Tim has been involved with the development and testing of performance assessment models and methodologies and the development of regulations and guidance for the geologic disposal of radioactive waste. And, recently, he has served as the technical lead for the development of regulations of high level radioactive waste disposal at Yucca Mountain, otherwise known as part of the 10 CFR, Part 63, and he's also been heavily involved in the lead at NRC of their Total System Performance Assessment code.

Tim?

MC CARTIN: Thank you. And, today, I'm giving actually a brief overview of the criteria for evaluating the performance assessment, and some of our risk insights. Please be aware that to do it justice, would take probably four hours to go through in detail. I will not be doing that today. I think you all can appreciate that.

But, what I want to do is give sort of the underpinnings, the main underpinnings for the performance assessment, some discussion on what we mean by risk insights, a word that's often used and everyone probably has their own definition of what it means, and then some risk insights that we have to date.

Next slide. And, in doing this, first I'll talk about, like I said, the safety approach of 10 CFR, Part 63, primarily with respect to the performance assessment. There are many requirements in Part 63. This is a small smattering, and like I said, just the other risk informed and risk insights.

Next slide. The safety approach, I'll talk of three aspects of the regulations: safety analyses, safety plans and procedures, and continued safety oversight. Part 63, licenses a potential repository at Yucca Mountain in stages. There are three main decision points. There's a construction authorization. There's a license to receive and possess. And, an amendment for closure. Those are three phases of that process. It could be as much as a hundred years for those three phases to go to completion. And, you'll see how is the performance assessment evaluated over this potentially hundred year period.

Next slide? First, safety analyses. Safety analyses are performed, safety assessments, we talked about screening features, events and processes. You then would, once you've done that, you've seen what kinds of things need to be in my assessment. I would then go to evaluate the radiological exposure. This includes both the groundwater protection and human intrusion. And, most importantly, the update of the safety assessment. For construction authorization, there will be a performance assessment. However, this will be updated at the time a license to receive and possess, and most importantly, at the time of permanent closure, possibly a hundred years hence. The safety assessment will be updated, taking into account all the information learned in the performance confirmation program.

And, so, that final decision to closure will make use of this updated assessment, based on, say, the past hundred years of testing and experiments. And, this is subject to NRC review.

I know Dr. Duquette raised the issue of alternative models, and one might question why are these things in the regulation. And, when you look at the requirements for the performance assessment, when we get a license application from the Department, as with every licensee, there's always questions the Staff has with respect to the application. When we ask questions, it needs to be related to licensing requirements. And, so, when you see the performance assessment, the requirements for things like alternative conceptual models, and the part that wasn't shown on Bob's slide is consistent with the data, and, so, that's, if we want to ask the Department, gee, you didn't evaluate this alternative model and we believe it's consistent with the data, we have a regulatory requirement that we can point to. And, so, all those things that are in there are things that we think are reasonable for the Department to consider, and it provides the NRC a basis for asking for what we call additional information from the licensee.

Next slide. In terms of safety plans and procedures, the top two are really more related to the operational aspect of the repository, where you train, test and certify and requalify personnel that are doing the operations at the facility. You also have emergency plans for potential releases, that's an operational aspect.

The second two, waste retrieval and performance confirmation, go hand in hand. The repository is required to be constructed in a way that the retrieval of waste option remains viable until the Commission makes its final decision on closure of the repository.

During that time period, performance confirmation information is collected. The performance confirmation program is designed to test and evaluate the assumptions that were used to make that initial decision at the construction authorization, and that could continue to change as time goes on. Clearly, science will advance. The Department is required basically to challenge their knowledge of the performance assessment. That program would continue until closure, and when I talked about the update, the update at the time of closure is based on this performance confirmation program.

So, a very important aspect of this. It's not a one-shot deal. We certainly need a performance assessment that can deliver the confidence in the strategy for the performance of the repository, but this continues to be researched and looked at up until the time of closure, and at any time if it's necessary for public safety, the waste would be retrieved.

Next slide. And, finally, there's continued oversight of safety. At the time of closure, the Department has to have a program for land use controls, permanent markers, records and archives. All this is to allow future generations to understand what was done there, and why.

In addition, there is a requirement for the repository to be monitored after closure of the repository. And, it's just a recognition that it only makes sense to continue to monitor the repository after closure. The NRC will not be there as an oversight because we will terminate the license. The Department of Energy would be monitoring, and the sole government agency for the repository. But, there is a requirement that needs to be approved by the commission for monitoring after the repository is closed.

Next slide. Those slides were really in my mind the regulatory background for the way performance assessment will be evaluated over the lifetime of the repository program. Next, I'll talk about what we mean by our risk informed approach.

In terms of the risk informed approach, what you're looking is to identify important parameters, models and assumptions in the performance assessment. You want to identify important uncertainties, and you want to focus the review on the technical support in the key areas of the performance assessment.

Next slide. In general, there is analyses done, the performance assessment has what could happen, how likely it is, and what's the consequence if it would happen. In addition, this calculation is certainly looking at the compliance with the dose limits in Part 63. However, I would say that if I tell someone the estimated peak dose for the repository is 5 millirem, while you can say, well, it's below the regulatory limit, I don't believe anyone has a basis for determining why should I believe that. And, that's where the risk informed process needs to look at intermediate results, other estimates in the performance assessment, to give you insights of why should I believe the 5 millirem.

It certainly is a number that's compared to, but I don't think, it doesn't give you any sense of why should I believe that.

Next slide. In terms of what I want to get to now is in terms of understanding the repository performance, which is the backbone of a risk informed approach. You have to have a good understanding of the behavior of the repository. And, here's where I'll say I'm hoping we're getting better. I believe performance assessment has let down both the Committees, the Review Committees we interact with, and our other scientists at the Commission for us, in that when we do our calculation of performance, we need to be able to present this information where the people seeing it can interact and bring their expertise to bear on this problem, and we can have a debate as to, well, do you believe this, and why not, and is this the right model.

And, over the years, I think we haven't done the best job we could in terms of providing the information that's amenable to having this debate, primarily for us it's with our Advisory Committee for Nuclear Waste, but we've made presentations to the Board, as well as presentations to the Board of Radioactive Waste Management at the National Academy of Sciences.

I think what I'm going to show you today, I don't think the actual numbers are that important, but I think the approach is what we're going to work on to improve on to provide this information in a way that we can get feedback, not only from our staff at NRC, but review committees. And, in terms of getting the risk insights, first is the inventory. What is the potential risk of the waste at Yucca Mountain. You want to identify the barriers important to waste isolation. What are you counting on to perform to maintain safety at a potential repository at Yucca Mountain, and what are the uncertainties.

Next slide. If I look at the inventory for the repository, and this is at the top, we have Americium 241, you can see, and I wish I could read it from here, but it's 54 percent of the inventory, slightly different if I weighed it by its dose conversion factor. But, what you see are Americium, plutonium, constitute the vast majority of the inventory, and this is at a thousand years.

It's interesting because generally when we see the dose calculations, we hear of iodine, technetium exclusively, and you can see technetium and iodine are a very small fraction of the inventory. If you look at it weighted by the dose conversion factor, iodine and technetium are less than a thousandth of 1 percent of the inventory in the repository.

While it's useful, and we need to look at iodine and technetium, from a perspective of the regulator, there's a lot more potential risk out there, why is that zero. That's one of the questions you want to understand. I understand iodine and technetium doses, why are these not showing up? Far, far more curies of those particular radionuclides, and we're interested in understanding why certain things are zeros, as well as what eventually gets out.

Next slide. Making this point in a more graphical way, if I look at five radionuclides, and I believe I have Americium, plutonium, neptunium and iodine and technetium, iodine and technetium are down here. And, this is the release out of the waste package. Clearly Americium and plutonium and neptunium are getting out of the waste package in far greater quantities than either iodine or technetium.

Now, let's look at what's getting out of the geosphere. Next slide, please. And, I purposely kept this at the same scale. The iodine and technetium has shifted a little bit, but it's pretty close to the same as what it was on the other slide. Americium, plutonium and neptunium are zero. That's something you want to understand why that's occurring that way.

Next slide. One way to look at the repository, and we've tried a number of different ways to present this information in a way that helps the staff at NRC have some perspective on what matters and why, and additionally to the Advisory Committee on Nuclear Waste for the NRC. And, the two standards or limits I'll use is, one, based on a release rate, and I'll look at a release from the waste package. And, if the annual release from one waste package is 10,000 times below the standard, I'll give it three L's. 1,000 below, two L's. 100 below, one L.

Now, why did I pick 10,000? Primarily because 10,000 is approximately the number of waste packages in the repository. If the release from one waste package is 10,000 times below the limit, that means even if all the waste packages were releasing at that rate, it would still be below the 15 millirem limit. And, so, to give some perspective, that's why the three L's are the way they are.

For delay on transport, now I'm not talking about a limit on release, but a delay, for other components of the repository, I look at delay time greater than 10,000 years is 3 D's, 1,000 years, 2 D's, and 100 as one D. And why am I using D's and L's? The next slide will show you why.

Next slide, please. And, what I've done here is looking at the effectiveness of the repository waste isolation functions, and what I have, not too surprisingly, the effectiveness is very dependent on the radionuclide. And, so, I have the effectiveness by radionuclide, I have the waste package, which is a delay time. I have a release rate from the engineered barriers, and here's where I'm using my L's, and a transport in the geosphere, and here's where I'm using the D's. Not too surprising, for the waste package, it's somewhat binary. And, this was a calculation based on average parameter values, and it works the same for all radionuclides.

Interesting for the release rate from the engineered barriers, where there's a blank, that means it was less than my lowest value. You can see from the waste form release, there really wasn't much effect, other than for technetium has 2 L's, a very small inventory, a release rate is somewhat effective if you're starting with a small amount. A radionuclide like these that have a large inventory, it isn't very effective because a small release rate, it's still a small of a lot, it can get you a significant amount of curies out.

I will say there is one typo, in that the iodine that has one L, actually should be two L's. Sorry about that. But, you can see solubility limits, there really wasn't much other than uranium. And then when you had the combination of solubility limits and limited water flow, there were some additional radionuclides.

One of the things that one would use this is for the different disciplines. You can see, gee, we look like we're not getting much from the waste form. For the material scientists looking at the degradation of spent fuel, do you agree with this? Solubility limits, not doing much, and there's ways to probe the different scientists. In terms of transport, once again, you can see I'll look at the saturated zone in the porous media, this is the alluvium, for the americiums and the plutonium that made up the majority of the inventory, you can see there's three D's. The delay time was beyond 10,000 years. That's why that curve, they were all zeros. Not too surprising. For technetium, it's a single D.

Iodine the same way. It sort of tells you why iodine and technetium show up.

This is a way just to get people thinking of how their particular part of the performance assessment fits into the whole. Truly, is the waste form, does it have that limited a role? Now, I will say possibly that limit of having to be 10,000 times below the compliance standard was too severe. I mean, that may be possible for that. But, it gives you something to look at to try to think through.

Most importantly, and I'll say the one thing, the benefit of coming and presenting things like this, I presented this to the ACNW a few times over the last couple years, gotten suggestions there, I've gotten suggestions at the National Academy of Sciences, and Jane Long suggested you really need to put this in terms of uncertainty. And, so, the next slide, I'll take the transport in the alluvium, or in the saturated zone, I'm sorry, next slide.

What I'll then do is go into a refinement of that table looking just at the saturated zone, that lowest line of that rather broad table, and looking at the alluvium, and there's retardation factors that can vary orders of magnitude. There's the length of the flow path, that can vary. In the fractured tuff, there's significance of matrix diffusion, and there's things that are going on there. Let's look at how these factors and uncertainty in these factors affect that overall behavior. Now, the next slide.

And, what you have here is once again, I've switched things up on you, in that I've put the radionuclides here, but I've looked at the distance of the flow path in alluvium, looking at the lowest, the shortest flow path in the alluvium, and the highest flow path. Once again, for americiums and the plutoniums that were delayed significantly, it didn't make any difference. They were delayed 10,000 years, regardless of whether the shortest or longest.

Likewise, you see a similar behavior for the retardation factor. Generally, these radionuclides are highly retarded, even at the lowest value for their retardation factor, and the lowest value for the alluvium length, it still is delayed beyond 10,000 years. So, you can see when you look at this, the uncertainty is telling you even at its poorest performance, it's still giving you quite a bit.

I will say one thing. One of the reasons for this, these nuclides, the reason they are the largest inventory amount, relates somewhat to their half life. They tend to have shorter half lives. So, there is a delay that if it decays away before it can get out, it's gone. And, so, it's much more effective for these types of radionuclides that tend to have the shorter half lives, whereas a radionuclide like neptunium with the longer half life, you can see the difference between the retardation, it's 100 years versus greater than 10,000 years. There's a significant difference there in terms of the behavior of the neptunium.

But, once again, it's a way to start thinking about the repository in a way that you can provide this information for us for other Staff members at NRC, the geochemists, the hydrologists, and talk to them about some of these things, do you believe this. I'd like to think that people, hydrologists, transport and review committees, can look at this and get a sense of, gee, you know, there's some other processes. I know colloids was brought up as something that could defeat part of the retardation mechanisms, but it puts it in perspective in terms of the behavior of the system. And, that's what we're trying to do, and I think it's been suggested that we could do this better graphically. I'm sure there's better ways to try to do this. We continue to work on it.

Drs. Garrick and Hornberger will have to advise us from this table that ACNW. We did make a commitment to them in the last meeting we had with them that they were supportive of this overall approach, but clearly the question that was asked about the engineered system with the drip shield and the waste package, expand that, the waste package, expand the release rates, and it's a way to get into the system. And, I know Dr. Garrick probably for his entire time at ACNW has always pushed us about a simplified performance assessment. In part, you can look at some of these things as a way to do a simplified performance assessment, whether it will ever get--maybe we'll do it now that you've left, Dr. Garrick.

GARRICK: You're harassing me.

MC CARTIN: But, once again, it's a way to--and, you know, we've gotten a lot of good suggestions. We hope to get more. But, I think the way you learn is you can provide information that people can react to, and you can get a debate going, and they can go back to their hotel room and think, gee, why should I believe that particular delay time, or that release rate, or something, and it's a way to provide a framework that allows people to understand what's significant.

And, clearly, the NRC, from risk informed, what do we want to look at? Well, clearly, here, we're very interested in the retardation. It's a significant effect, but it doesn't have to be at its highest value. It's just, gee, at the low end, are we certain of the low end of that particular value? For neptunium, it's a little more important. There is a variation. But, it allows where do we want to dig in more in a potential application from the Department of Energy.

Next slide. I think that's it. In summary, the idea of risk insights, and to me the heart of the NRC review is a comprehensive understanding of the repository system. And, we want to identify the important models, parameters and assumptions, look at the uncertainties, and, you know, this provides in my mind what we mean when we say a risk informed review. We understand what's working and why, and we go into the areas most significant and explore the basis.

And, I'll be happy to answer any questions.

ABKOWITZ: Thank you, Tim. Questions from the Board? Dick?

PARIZEK: Parizek, Consultant to the Board.

The DDD, LLL, are those quantitative through model runs that you made?

MC CARTIN: Oh, yes.

PARIZEK: I mean, you folks have ground along and as a result then do the ranking rather than sort of a matrix guess as to how individuals feel about this?

MC CARTIN: Right. No, that was done based on running our performance assessment code, and it was sort of a--we debated whether should we put the actual numbers in. We thought the letters were better because the numbers, it's hard to look at quickly and get a sense, but when you see all those D's, okay, it's all greater than 10,000 years. And, we felt rather than numbers, that would be all over the map, you know, some would be 1,200, 2,500. We thought it was easier.

PARIZEK: A follow on question. Do you have a similar table that's being developed now for, say, 100,000 years, or something with a longer performance period based on the--

MC CARTIN: Well, any of those tables, they aren't based on any particular compliance period. They were just based on--you're right.

PARIZEK: Some made the 10,000, or slightly more, you're happy. But, now if they have to make 100,000 maybe you won't be happy, or somebody won't be happy.

MC CARTIN: Well, yes. I mean, I will say for the americiums and the plutoniums, that could have been a million years. I mean, they just don't get out. They decay away, and so that--but, we haven't looked at going beyond that at this time, in that we clearly have the calculation. We can go further, but we haven't.

ABKOWITZ: David?

DUQUETTE: Duquette, Board.

A couple of comments. One of those is that there is at least, or people have expressed some concern to me that once a license application is granted by the NRC, that science will stop on the project, or at least slow down on the project. That leads me to a couple of questions. The other comment I would make is I've heard comments that NRC is badly understaffed.

Now, if I take a look at your having to review several million pages of documents over some next upcoming period of time, do you have any feeling for how long that's going to take, and whether NRC will have any input as to the continued science that should accompany any repository at Yucca Mountain?

MC CARTIN: First, the latter question in terms of the continued science at Yucca Mountain. There are at least two avenues that NRC will be active in with respect to continued work at Yucca Mountain. First, the performance confirmation program is a commitment by the Department of Energy where they are going to challenge over the next hundred years the performance assessment and the basis that the original decision was based on. And, so, that's a commitment, and the NRC would have oversight of that commitment. So, that's one.

Certainly, NRC will inspect those tests, is an option open to the NRC. There also are license conditions that the NRC can impose. You know, I'm not going to say that we would, but certainly if there were certain tests that through the course of the hearing, there were certain things that needed to be done, even if they didn't fit into the performance confirmation program, the NRC can put a license condition, say you have construction authorization, you're going to do this test before we grant you a license to receive and possess. So, there are avenues for the NRC to impose certain tests, et cetera.

With respect to the NRC being understaffed, I've been at NRC for around 23 years doing performance assessment for high-level waste, and you always want more people. We work extremely hard at the NRC. I believe we have the staff capable to review the license application.

DUQUETTE: In what time period?

MC CARTIN: Congress has mandated a three year time period, with an option for four years. We will do everything in our power to meet that schedule.

DUQUETTE: Thank you.

MC CARTIN: Thank you, Tim.

Okay, our last formal presentation today is going to be on EPRI's approach to TSPA, and more specifically, their latest results. And, giving that presentation, will be Mick Apted, who is the Executive Consultant and Operating Manager for Monitor Scientific. Mick has had over 18 years of experience in nuclear waste management R&D, primarily in waste package, geochemistry, and performance assessment areas.

One of the projects that he is the lead author of is the EPRI Risk Assessment Model for High-level Waste at the Yucca Mountain Site. And, I might also point out that Mick received his Ph.D. from UCLA in the field of applied geochemistry and material sciences, and I believe there was a

Professor Garrick at UCLA at one time.

GARRICK: Well, adjunct professor.

ABKOWITZ: Okay. I was just--I wondered if their paths ever crossed during that period of time.

I would like to ask Mick to be as concise as possible in his presentation. We do have a public comment period that's scheduled to begin in roughly 25 minutes or so, and that is a period of time that's always been extremely important to the Board, and we recognize there are individuals that have waited a long time today to have that opportunity. So, we will honor that as best as we can.

APTED: Thank you, Mark. And, I thank the Board for the opportunity to speak in front of you today. EPRI always welcomes the opportunity to engage in dialogue I think on what we all feel is a very important, urgent, national issue on the management of spent fuel and high-level waste in this country.

I will note that my boss is John Kessler, who cannot be with us today. There's a National Academy of Science meeting, as probably many of you are aware, on the issue of the post-10,000 year compliance in Washington.

So, today, if there's information as a follow-up that I can provide or if you really don't like certain parts of what I have to say, please contact me at this number. If there are things you really like about the talk, please contact my boss.

And, lastly, I'll also make the same disclaimer as I think for the Board, that while I'm here speaking of EPRI's program today, I'm not speaking for EPRI, and I think you appreciate the difference between Mick Apted's opinion on certain issues, and so on, versus a formal position that EPRI might take on the same issue in a more prepared analysis.

Next. This is the outline today. I'm going to talk a little bit on our role, achievements, approach, a little bit about the structure of what we do, some of our recent results. I won't touch upon the deliquescence. We already made a presentation to the May Board, and if you new members are interested in sort of our perspective on that, they can I think go back to that particular presentation. I will touch upon the igneous event/volcanism because there's a very recent report by EPRI on that. And, then, I'll talk a little bit about our future directions.

Next. EPRI's role, basically to conduct independent, technically defensible analyses of the long-term isolation of nuclear waste within a repository at Yucca Mountain. And, then based on these analyses, we're really anxious to help provide insights and communication to those insights to EPRI's members, EPA, NRC, Department of Energy, various review organizations, such as the National Academy, this particular Board, the ACNW, and of course to the general public as well, because I think all of these people have an important stake in understanding the basis by which safety is going to be assured for Yucca Mountain.

Next slide. Okay, based on my good geologic, geochemical training, you always show a location map, I'll compress all of Bob's talk into this little bit of piece of the pie, but obviously we're talking about the repository system, the engineered barrier system part of it, as well as the biosphere here. And, these are some of the important components that Bob talked about.

Achievements since 1990. There's a large number of them. I'll particularly draw attention just to a few of them. If you're particularly interested, we've been doing our own TSPA style analysis over this last 14 years. Not every year, but almost every year, we do an analysis, and if you're interested in obtaining these reports and seeing the progress over time, and evolution of our thinking over time, I'd be glad to provide those documents to you.

I think it's fair to say that really, a large part of this what is really now TSPA was certainly encouraged by EPRI in the early 1990s. We've had various inputs to important stages along the way, the National Academy. We've been involved in looking at alternative conceptual designs, models and data. I'll talk about some of that today. And, some of these approaches that where we're trying to show the relative effectiveness and contribution to isolation of the different engineered and natural barriers of the system. And, remember my barrier, we mean either a feature, a component, or in some cases, even a process.

Currently, one of the key things are the "what if" scenarios that we engage to study. Before this year, some of the particular focuses have been on areas such as climate change, the issue of juvenile fabrication defects. In fact, we'll lay claim to one of your alumni, Dan Bullen, who also in the past has worked with the EPRI team on exactly this issue.

In 2004, we have several important reports on the igneous eruption event, deliquescence, and microbial influence corrosion. And, in progress, since we're on a calendar year, our year is not yet over, we're also looking at the issue of tunnel stability, seismicity, colloids and sorbtion issues that have been raised by the State of Nevada.

Next. Okay, what's been our approach? Basically assemble and maintain a team of experts to review publicly available information related to the design and performance of the multiple-barrier repository concept for Yucca Mountain. A very key part, emphasis on multiple-barrier, not drawing too much attention, all of us as experts, as a geochemist, I was guilty of this as anyone, drawing attention to the things that we know best, and sometimes not seeing that there's a larger set of redundancy to this system that really is the hallmark for safety.

Based on this review, we identify, defend and integrate a credible set of best estimate assumptions, models and data and associated uncertainties into our TSPA code called IMARC. Then using IMARC, combined with our expert judgment, we use this to evaluate, as Tim talked about on a risk informed basis, the long-term performance of barriers for the expected evolution, as well as a set of credible "what if" alternate scenarios.

Okay, I won't spend much time on this. I've got a large array of people. Sorry, Charles, a name I misspelled was yours, but there's a wide range of topical areas that we bring together sometimes for the purpose of a single workshop, sometimes as a continuing basis to support our effort in model development.

This is the monitor staff, and actually the boss of bosses, this person who happens to be my wife and actually owns the company.

Next. Okay, EPRI uses a logic tree approach for probabilistic TSPA, rather than a Monte Carlo. There are a number of reasons for that. I think one of the first is we find it's a very flexible and transparent approach. Really, it's been an excellent--we've got excellent feedback from people when we're able to show exactly how we put our models together in a very visual sort of graphic way. People, both technical and non-technical people, get it. Now, also, that leads to sort of our next advantage that we've found, is that it's very easy, this is sort of a given node on flow factor, or let's say solubility alteration.

If someone has an alternative model that they want to put in there, it's very easy for us to pull out our expert model and adopt their expert model, and put it right into the system. Some cases, it's not a question of alternative model, but just alternative bounding assumptions on the data, or what did the data tell us when we look at DOE's information. We also have the latitude of looking outside of DOE's QA program and looking internationally when people are collecting this same information that could be relevant to Yucca Mountain.

There's also been, in this type of format, I want to say a very, over the last 14 years, strong evolution in models, too. We've improved models, as we've looked at alternative conceptual models, seen that merging data is now supporting one versus maybe a previous model, we've actually substituted models over time to better match what we feel is the new emerging information from the site.

So, not only is we allow to test alternative conceptual models, but it's allowed us to build in the flexibility of putting new models in as they become supported by the credible evidence.

I think there's also been an evolution of nodes. One of the things I'd point out is that the number of nodes started at about nine. I think it's about 25 nodes now. We have a certain amount of expanding of certain areas that we find are important, some of the issues about the engineered barrier system, for example, have been expanded. Other topics, when we've looked at them from a sensitivity point of view, we've been able to contract those nodes, actually sort of simplify them. So, again, we have an evolution in the complexity of this structure over time.

And, lastly, I just want to point out that the type of information that goes into these nodes ranges from everything simple expert judgment, lookup tables based on more complex data, all the way up to models that are every bit as complex as the one that Bob has talked to you about from the project.

Next slide. Okay, one of the areas, for example, in terms of our approach is simply looking at climate, a certain specific conceptualization of what the future climate in the next 10,000 years might be, and looking at actually the infiltration rates, that is, the water that gets through that upper soil there, down into the mountain.

Next. We've also looked very attentively at this issue of whether the support that cladding might give us in terms of further protection. It's going to be an integral part of key waste in the system that we've heard about. So, we've looked at seeing to what degree some sort of isolation, especially containment credit, might be drawn for the cladding under conditions of either water dripping or whether it's just no water dripping, but eventually degrading over time.

Next slide. Okay, one of the areas that we've really pushed, and myself in particular, is looking at diffusive release in the EBS as a key component for this key, if you will, barrier. We feel it's important because it allows to consider release both from packages and dry areas which previous, because there was no advective flow, were treated as if there was no release. If there's a continuous pathway from such areas, it's still possible to get very, albeit, small release from such packages.

We can also look at releases from packages where there may be advective flow, but because of constraints of the nature of the failure, that it's very localized or pinhole, there's not advective flow through that package, but there still is the potential for release from that package.

These are just other types of bounding conditions that we've put in there. And, basically, I'd say diffusion to partially saturated porous corrosion products provides extremely slow release from the EBS, and possibly what we're looking at right now is colloid attenuation.

Next. This is just to show, for example, for the neptunium 237 isotope, the difference in looking at an advective pathway type versus the diffusive pathway for a similar package.

Next. Okay, EPRI approach to the normal release case. Bob's terminology was nominal release class. Basically, these are the factors that we've put in there, climatic change, much of the same topics that Bob has talked about, evaporation, condensation, looking at container cladding as a precondition for beginning of release, drip shield failure. We've looked extensively at a lot of "what if" issues about drip shields and their role.

Advection/diffusion through the UZ, and saturated zone, out to the 18 kilometer fence post. And, we've looked at, as Bob has also laid out, the sort of perturbations to the normal release mode, igneous events, deliquescence, colloid, seismicity. These are ones that are currently in progress.

Next. Bob showed you the lake. Tim sort of waded out a little bit in it. And, I'm going to jump right out in the middle of the lake and show actually some long-term performance assessment calculations for the whole suite of key radionuclides contributing to dose. I'll point out that one of the things that I don't necessarily--you need to consider is not only that the primary source of neptunium 237, but some of the daughters growing in from some of these isotopes become very significant contributors. The thorium 229 isotope particularly has a very high dose specificity impact.

So, again, 15 millirems would be about at this place. Remember, the sort of natural background is even much higher than this. So, these are the current, our analysis for the nominal release scenario.

Next slide. This gets ahead of it, but in a little bit, I'll talk about some of these sort of one-on, one-off barrier neutralization examinations that EPRI has made. This is simply one of the results for now looking at the normal release case, but with no contribution from the waste package.

There is a delay in release because of the heating, in terms of certain drives, but there's no containment here, there's no contribution from solubility or dissolution rates, some of those same features that Tim was showing in his graphs. And, the point is that this even in this kind of condition, the peak release we come out at is still well below the background, natural background, in the area of Yucca Mountain.

Next slide. Some of the differences, and these tend to change. I haven't seen TSPA-LA, so I can't--some of these may even be out of date, so treat them with a certain trepidation. EPRI assumes one early container failure. They've sometimes approached this more stochastically. Generally based on a lot of our analysis of the literature, assigned better cladding of container performance.

Remember, we're often able to go to best estimate. Bob and the project in general are often, because of their need to approach licensing, are forced into a situation where they have to take a bounding or more conservative approach. So, this explains some of the differences. We handle time-stepping differently in our program. We have some slightly biosphere dose conversion factors, and so on.

Next slide. One of the things that John Kessler is particular proud of is sort of looking at this idea of essentially a one-on rather than a one-off analysis, where we started by eliminating all the barriers, and then dialed in in a sequential, one after another, 13 potential barriers, and remember, these are processes or features or components, in the system here, and basically trying to identify their relative contribution to isolation.

Next. Rather than go through the whole report, which is several hundred pages, I'll go right to the conclusions, and you'll have to go to the report to see if you believe them or not. Basically, many barriers that really do contribute substantially, not all of the eggs at

Yucca Mountain are simply into superduper waste package. You will sometimes hear that alluded to. That's simply not true. The amount of performance depends on what other barriers are assumed. We find that you have to look at, in a sense, what particular barriers you want to add first to see their relative magnitude. If you add solubility first, actually it has a very big impact on the overall isolation. But, the point I made earlier that natural barriers alone do reduce doses to below the natural background level.

Okay, in the remaining four minutes, I have allotted myself now, we'll talk about the igneous event/volcanism. This is a wonderful slide I borrowed from the program. I'm going to talk a little bit about some of the analysis here that we've done. If you're interested, we're giving an hour and a half presentation to this to the ACNW on Wednesday and Thursday. I don't know which of those two days we're giving a very full treatment. So, this is a short encapsulation of it, and I'll be glad to send you the report now, which is published.

But, some of the features that we looked at, first of all, what was the probability of the event when we looked at this. What are the best natural analogues for this event. Is it something like Krakatoa or is the type of volcanism we're dealing with related to a much smaller type of event. What are the appropriate analogues. We feel that's an important issue.

We looked at issues in terms of the early thermal pulse. Will that deflect the rising dike, so that during early time, you don't have--you have a lower reduced probability of event intersecting the repository.

We're using actually a code, looked for large energetic events actually from meteorite impacts and nuclear bomb testing, something like a volcanic event is a rather low end of the energy spectrum in which it's calibrated for, but we've been looking at again, what happens when this dike first intersects the drift. Are there superpressures that's been speculated? Does a crack open? Do we get sort of a dog leg where the pressure runs down and cracks open, something further from there? All of the analysis that we've had shows that that just doesn't occur. The pressures that develop in the drift are very low here, insufficient to open fractures further down, and that the maximum peak pressures, which are sufficient to open fractures lie directly above the dike.

So, in our model, the dike rises straight right through the repository. We also looked at the--let's go to the next slide. Well, let's go to the next slide.

What I had was a demonstration of that sort of high energy simulation where we actually show sort of the simulation of both pressure, temperature, evolution in the drift. Unfortunately, the map doesn't go on to a windows machine.

We've looked at contacting C22 by high temperature, this is 1200 degrees centigrade, for from one hour to one month, although three to five days is really the time we expect in which molten magma will exist before it begins to really form permanent crusts around any packages. The material is still intact after one month, we see some surface voiding down here, but basically no evidence for granular attack or any other degradation mode.

Next slide. We've also looked at the kinetic impact of--actually, we looked at simulations up to 100 meters per second ascent rate. We find that the package is very durable. And, these ANSYS calculations are there's, of course, destruction of some of the internal structure within the package here. The actual outer part, the C22 is surprisingly durable.

I'd really point out that one of the differences, we've heard from Bob's talk and our approach here, is that EPRI is putting a lot of attention in looking at the engineered barriers and its interactions with magma. Conservatives, I think Bob mentioned, they're not looking to take any credit at this stage for this type of protection. But, basically, we looked at events that are probably ten to--well, ten to ten thousand times more energetic than really is likely to occur in a dike event, and the packages remain intact in this simulation.

Next. When we look at our igneous case, now this assumes event probability equal to one, so you would take this curve and multiply it by that very low probability of the igneous event. Okay? Don't go home and say, oh, this is what EPRI's idea of an igneous event is. This would have to be multiplied by one times 10^{-7} annual probability. So, move all your curves down accordingly. Okay? Negative seven, yes.

Okay, next slide. Now, that involves a log, you'd have to really--that involves a lot of attenuation mechanisms, things that we think will occur, the delay, prevent, other releases, and this is even the case when we assume that releases do occur. But, again, remember you would have to normalize by the probability, so you would bring these curves very far down.

Next. Future direction for EPRI? Basically we're going to continue any new "what if" scenarios as them emerge, looking both at probabilities and consequences, compare and contrast DOE and NRC approaches. I'm looking forward to the TSPA-LA, and TPA Number 4, I think it is, Tim, when they get published, EPRI will jump right on that and we're going to do a side by side comparison of exactly the models, the data, the assumptions that the three of us are using, which I think would be a valuable contribution when we begin to say why is our results different from someone else's.

I should also point out that EPRI also has a very active program in two other areas. One is preclosure issues, and the other is evaluation of transportation risks. In fact, EPRI is taking one of the leads in cofunding the National Academy Panel right now, it's working on that topic.

And, lastly, work after the license application submittal, looking ahead, to evaluate that LA and the supporting documents. Are they adequate? Will basically involve even a larger review group at that point. We're going to use the IMARC code and some related analyses codes, more detailed codes, to develop some independent assessments. And, I'm going to really stress the view that we're independent of the project, we don't rely on the project for anything, other than looking at their published documents, and using those in our own judgments in terms of what we select to include or not to include in modeling the same situation.

Thank you very much.

ABKOWITZ: Thank you, Mick.

I'd like to start off with a question that if we could go back to I think it's Slide Number 17. That one, thank you. This is just an idea of what I'd like to bounce off you. For a while, I've heard this term defense in depth for two and a half years now, and, you know, it sounds great, but it doesn't seem like it's been very measurable. And, I was wondering if there may be an opportunity in the framework that you have here with the one-ons where if you altered the sequence of the one-ons over several different runs, you could then start to measure the net difference in impact from whatever conditional location it's in. And, you actually amass a data base of several different observations that you could regress across, or do some type of correlation coefficients. Am I way off base, or is this an opportunity--

APTED: No, we're right now planning, because this previous was focusing on a 10,000 year time period, and I think if we now looked at peak dose, we'd have to find, you know, certain--there's going to be winners and losers among our nodes and processes. I think like the National Academy report in '95, they pointed out something like containment is probably going to be rather de-emphasized in the longer term assessment for peak dose. Other things will be shown to be much more important.

So, yes, taking on board what you said, exactly, try to look at this in a more systematic way to really try to show what is important.

ABKOWITZ: It seems to me that you either could come up with some type of correlation table to show which barriers are highly correlated with one another from an added safety standpoint, or which ones, if you did a regression with the data that you collected, which ones are more co-linear with one another. Just an idea of how to maybe quantify--

APTED: I should point out that, I mean, one simulation through when we do maybe 100 to 200 per sort of total nominal case, takes about two minutes to six minutes depending on what's going on in the UZ zone.

ABKOWITZ: Dick?

PARIZEK: Parizek, Consultant.

I'm looking at your diagrams, it's analysis of dike packages. These are model run--

APTED: Yes, that's ANSYS calculation. That's right.

PARIZEK: Now, these are Megan's type analyses?

APTED: No, this is another group that EPRI has on board that's doing I think other evaluations of dry cask storage as well. Although I managed the overall input of the program, if it's existing EPRI sort of complex, the same way with the corrosion tests with the magma, those are done at EPRI facilities. So, it's not Megan's work, it's another group's work.

PARIZEK: But the ascent rate assumptions here seem reasonable or are bounded by--I mean, this is the model runs?

APTED: Yes, we started with what we thought was a low--you know, when you look at recent information, we find that the temperature, actually, when you go out to some of the analogues at the site are probably more like 1,000 to 1,100, so the temperatures were too high we used, and the ascent velocities at .1 meters per second, which we thought was sort of upper bound reasonable, were causing no damage at all. So, we stepped up the energy to try to see where we actually end up sort of getting into trouble with packages breaking open with the kinetic impact.

PARIZEK: So, no packages are breached, according to the runs?

APTED: Correct.

PARIZEK: Thank you.

ABKOWITZ: George?

HORNBERGER: Hornberger, Board.

Just a quick question, Mike. I was surprised at your three to five days to get magma to solidify. Here you have this waste package with a pretty amount of thermal inertia, it's cold, and the magma comes down, I would have thought that you would have gotten a crust, a Basalt crust over the surface much more rapidly than three to five days.

APTED: And it is location dependent. Remember, there's expanding greatly somewhat with time from the initial geometry, but we're looking at maybe anywhere from one to three packages in the conduit over the duration. That reflux of new material keeps the solidification in that region to a little bit longer. Ones that are further off the drift, you know, the conduit access, you're right, it's more like minutes.

ABKOWITZ: Okay, thank you very much. Oh, I'm sorry, wait. Dave Diodato?

DIODATO: I have just a quick question. Diodato, Staff. Well, maybe two quick questions.

First, I appreciate your rapid run-through there. I guess I will restrict it to one at the request of Dr. Abkowitz. Okay, on this tree, this decision tree that you have here, logic tree approach?

APTED: Yes, it's a portion of it.

DIODATO: Okay. I'm just talking about the philosophy, I guess, or the methodology. I look at that, and I can understand how attractive it is to make a continuum problem fundamentally in nature, into a discrete problem. So, what it says is really the weights that you put on these different branches of the logic tree, and I'm sorry, I don't know what slide number that is. But, EPRI uses a logic tree approach to probabilistic TSPA, not Monte Carlo. One before that. There we go. So, the weights on these branches, I guess, are determined by expert opinions; is that correct?

APTED: Correct.

DIODATO: Okay. So, the values of those weights are significant; right? They make a difference?

APTED: Very much so.

DIODATO: In what the results are. Do you ever do any independent testing of your sub-models, analyses and assumptions that are inherent in this discrete simplified approach?

APTED: Actually, this year, we've engaged, sort of begun a benchmarking against Analytic Solutions on a lot of the sub-models where possible. The UZ zone in particular is very difficult, and what we're looking for is actually, I think when TSPA-LA or, you know, the NRC codes come out, an opportunity to do some benchmarking with those. But, yeah, in some cases, they're almost like the climate stage is really just an abstraction from Austin Long, based on his experience, and so on. There's no modeling behind it.

Some of our lookup tables, like Ben Ross's, we reduce that whole sort of thermal hydrologic system, we do a lot of modeling on the side, and create a lookup table basically to derive some of the estimates on values and on their weighting.

DIODATO: Second question that I was going to ask was about climate, but I won't ask that. But, I will follow up on this. I really meant when I asked about testing of the assumptions, more like testing against actual real data, not just analytical solutions. I assume that the analytical solutions, the models, conform to analytical solutions--mass and that sort of this. I mean, we'll give you credit for that automatically. So, is there a data program to evaluate whether--

APTED: Well, in some cases, yes, some no. I mean, you can take something like solubility where the time scales are permissible to get that kind of testing and validation, although, again, you don't want to use the same data you're using, you know, to calibrate the models, to also say you're confirming the model. On something like climate change, you know, it's not possible to run climate 10,000 times for 10,000 years in the future to get a confirmation. So, we have a range.

DIODATO: Thank you.

ABKOWITZ: Thank you, Mick. And, I'd also like to thank Bob and Tim, as well as Mick, for giving us a lot of information in a short amount of time. And, at this point, I'm going to turn the program back to John Garrick.

GARRICK: Thanks, Mark. I want to add to Mark's thanks, the same thing for all of the presenters today. The presentations were outstanding. The graphics were fantastic. And, it was very appropriate for the new Board, the overview that was provided, and we know how much work it is to develop this level of presentation, and we're grateful for what you've been able to do. So, thank you.

We've now come to the point of our day's activities, it's very important. The Board has been very attentive to the process of allowing the public to express themselves on issues and views, particularly of the activities that have been presented during the course of a given meeting.

We have received an interest from four people to make comments, and they are Dr. Jacob Paz, Sally Devlin, Grant Hudlow, and Susan Lynch. So, why don't we take it in that order, and start with Dr. Jacob Paz, if he's here.

PAZ: First of all, thanks to the Board. I got the letter that May the 2nd, which I raised two questions. Number one, they asked me to submit a proposal on risk assessment, and I'm going to do it. Second, another issue is regulatory, and it's very clearly indicated that the regulation can be changed if EPA changes. I have no problem, the State and DOE can comment, but I don't take any points, I'm staying neutral and following what is the results.

What's happened in August was I was interviewed by Keith Rogers, an advisor, and stated the following: that DOE basically doesn't have any regulatory requirement to calculate the combined effect between chemical and radionuclides. I strongly disagree, and why?

I cited NEPA, which stated that you must assure that for all Americans safe and healthful, productive, and so on. Section 101, to attain the widest range of beneficial uses of the environment, with degradation, risk to health or safety. And, my question is did the DOE comply with the letter of the law and inform the public on the potential health hazard of mixtures?

Second, the regulation very clearly specified that we have to provide environmental information to the public on complex mixtures. This has not been done. DOE did not provide factual evidence to support their conclusion, I think very little.

DOE did not disclose the importance of the cumulative health effects of mixtures as required by 40 CFR, Section 1507 and 1508. There is also an NRC guideline and EPA guideline on mixtures.

Then I'm just quoting, it's a very interesting section. If test data indicated from chemical or mixtures a significant risk of serious human being from cancer, gene mutation, or birth defects, the Administrator must initiate appropriate rule making. This is a very clear regulation.

And, here's an example which I'm using, the bystander effect, by Volkes (phonetic), and showing the low level of radiation can cause genomic instability, gene mutation, chromosome aberration, and so on. It's possible and probably that they could have to intervene, because DOE did not take any action. And, I will challenge them in the license application.

There is a quote from the Las Vegas Review Journal. "An EPA official who spoke on the condition of anonymity said it's not out of the question that the issue Paz raises eventually might have to be addressed after DOE officials apply for a license for the repository from the Nuclear Regulatory Commission." Quite significant.

In conclusion, yes, I'm challenging the Federal regulations over health risks at the proposed high nuclear waste repository based upon sound scientific reports from the literature we provided to DOE. The issue must be addressed by research, not by calculation. Public health comes first.

Thank you.

GARRICK: Thank you. Sally? Sally Devlin? Oh, there she is.

DEVLIN: Good afternoon, and thank you for your patience. And, my name is Sally Devlin. I'm from Pahrump, Nye County, where the repository is, Nevada. And, it is my pleasure to have been among you for the last eleven years, and officially, I greet you and say welcome, you're my fourth Board that we've had to train. And, I can't wait to read all your biographies and find out who is the specialist among all the specialists. So, welcome to Nevada officially.

And, I do want to say this. For those of you who have not been down in the mine, as we call the tunnel, may I just say this to you, if you've ever been in a coal mine or a gold mine, just picture it, what do you see? Everybody naked. It's hot, it's humid. The reason it's closed all the time is my bugs and the fungi are eating all the equipment, because there isn't any proper ventilation. So, therefore, may I suggest when you take the tour, that you be comfortable.

I have been with this Board in the middle of winter when they went in with ear muffs and they came out naked. So, that's all that I can say. It's true. You just ask them. So, remember that.

GARRICK: I don't know about these past Boards. It's going to be hard to live up to that one.

DEVLIN: You'd better believe it. Absolutely sweating. It was just horrible. So, remember you're in 85, 95 degrees down there, and it's full of mold and it's full of fungi.

But, that's not why I am here today. I am here at--Tim, where are you? There you are. I never have yelled at anybody in the NRC, and you're going to be the first one. You did tell the truth about the 100 years. I think it will be longer. But, you insulted the public with your radionuclides going from hot to nothing. And, I want to inform you that there are 111 isotopes, uncles, aunts, dogs and cousins, of uranium alone, and probably plutonium, too. And, you took these few, and said they go down to nothing. I disagree thoroughly, and I hope we'll discuss it later.

But, why I'm here is this is going to be fun, Ladies and Gentlemen, and the subject is earth currents not addressed by Yucca Mountain. And, this is what they are. The potential danger from lightening at Yucca Mountain has not been addressed. The danger from lightening is not only to people, but it may cause fires, but it has the potential to destroy all communication equipment.

There are many types of lightening. Most people are aware of sheet and streak lightening. But, the most dangerous are ball and plasma lightening. The ball and plasma lightening give no warning and it can appear at any time emitting upwards of 60,000 volts. And, I happen to know that it goes to 100,000 to 200,000 volts, whatever volts are. And, they can do tremendous damage. They are prevalent on the test site, and of course Yucca Mountain is on the test site.

The test site group have known about it. They've had all kinds of fires and hazards and things, but Yucca Mountain has never looked into it.

The reason that I'm doing this, is this deliberate oversight? And, this is because of Nye County. Nye County is the worst county in the entire state. They make contracts and then the contractors come back and say we need more money, more money. And, I do think since you're applying two contractors that are contractors required to put this potential problem in their contracts, and that's my questions. Because if the damage does occur from lightening, and it would require expensive change orders, you should be prepared for it, since you haven't addressed it.

This is Paper Number 5,000,000,001. You already put in 5 billion pages; right? Close to it? All of my research comes from NASA, and my report is from CCSN in Pahrump. And, as everybody knows, I'm a twelve year student. And, I thank you for helping us get this facility for curious students like myself.

This report will also be sent to the proper agencies, because I personally feel lightening is a real risk. And, I do want you to know I spent 20 days on a cruise in Scandinavia and St. Petersburg, and when I came home, we had had terrible lightening, flooding, and so on and so forth. You saw about Death Valley. But, it also happened in Pahrump.

And, the only thing I forgot to unplug was my refrigerator. The compressor blew from a lightening strike, and I do have a surge protector. So, this is what can happen. So, lightening really means something very personal to me, and I have the 142 page report, but I just did this one pager for all of you.

So, thank you. Again, welcome. Come back again. I hope the meetings will be in Pahrump, and I will only give one instruction. You do not wear the uniform. You wear blue jeans and comfortable clothes, or we'll think you're INS or

IRS, and we will shoot you.

Thank you.

GARRICK: Grant Hudlow?

HUDLOW: I'm Grant Hudlow. And, there's some things I think the new Board needs to know. John Garrick and John Arthur are brilliant, competent, turn around experts, like Lee Iacoca, Jack Welsh, and other outstanding CEOs that you may know about yourself. Those are two people that when they say something and work on something, it's going to get done, and it's going to get done right.

They need your help. What we have a background of is 20 years of bad science, phoney science, and in some cases, fraudulent, deliberately fraudulent science done by gangsters. The murder of Paul Brown, the investigation into that, showed that up.

So, when you're looking at the basis for all these KTIs, you have 20 years of a mess underlying it. And, we have a couple of brilliant gentlemen that are trying to straighten that out. They don't have time to do it before the license application, I don't think, and certainly not before the construction application. It takes a while to undo that kind of a mess.

NRC has not detected any of that, and I think that's a travesty. I think with the leadership of John Garrick, that maybe they can step up to the plate and start to notice that they do have a mess.

In Tim's presentation, there are all kinds of details that I'm appalled that somebody from a regulatory would get up here and talk about.

The job that John Garrick and John Arthur have is to keep this mess from killing the 20,000 civilians that DOE has predicted will lose their lives because of this mess. So, you have to kind of put that in perspective. Each one of these waste casks has 68 spent fuel rods in it. And, we talk about breaching the cask as though it isn't going to happen. The cask has 170 pound psi seal on it. You heat it up to 800 degrees, you've got 2200 pounds of pressure inside of it, with the cooling down magma, you heat it up to 12,000--1100, 1200 degrees, you've got 3000 pounds of pressure in there. With 170 pound seal on the cask, it's ruptured right at that point.

Each of these fuel rods, when it comes out of the cask, the tests have shown will be 50 to 90 percent respirable dust. It's going to go clear around the world. Each of these fuel rods has the contents of several Hiroshima bombs in the fallout, and there's 68 of them in there. We're talking about something that makes Chernoble look like a Sunday School picnic. So, the responsibility on the Board to straighten up this mess and to help straighten up the mess is incredible.

Besides John Garrick and John Arthur, there is another light at the end of the tunnel. Sandia with Z pinch fusion have now achieved what we've known since the Sixties again, that there's 72,000 tons of waste that can be converted into a trillion dollars of electricity. In this society, money talks.

On the other hand, the way we're going now, in 20 years, there would be no money for this project. So, you're looking at the various projections, they're going to stop in 20 years, because there's no money coming in to handle it any further. So, at what point are you going to walk away and leave this mess?

So, I think we need, the industry doesn't understand transmutation. The scientists that discovered it in the Sixties, ran it again in the Eighties, now are doing it again, don't form businesses, they wouldn't know a commercial process if it fell on them, so the industry not paying any attention to it, we need some push to get that done.

The other thing that's missing from all this, I've heard the word mentioned a time or two, are microbes. I'll give you an example in the mercury contamination. We've started looking at mercury contamination in gold mines all over the west, and we found that there are microbes that take this mercury out of solution, they put it down in the mud, it's insoluble, wonderful. Problem solved.

The next thing we noticed is that there are other microbes that take it out of the mud, put it back into solution, and it's in the drinking water again, to the point that you're being warned not to eat ocean fish over so much a week. That's a big contamination. We've contaminated the ocean to that degree, and there are lots of strains in Nevada. People are wringing their hands. What do you do with a mess like this?

For those microbiologists in the groups, the thing that microbes do next is mutate, and the thing they do after that is change, if the conditions change, they change, they do something completely different, a whole new group of microbes shows up. Where do they come from? Typically, a microbe population has 150 different species, and they mutate, change, and so forth. Are you going to model something like that? I don't think so.

How are you going to run that through the however many nuclides, radionuclides are running lose after the canister splits open? What are you going to see up there? You're going to see the effects afterwards, just like we have from every other DOE mess that's been made on this planet. And, to say nothing of what the nuclear industry itself has done, and have managed to cover up so far of the leukemia clusters in the kids around these nuclear plants.

So, what I'm saying is you have a couple of brilliant, outstanding leaders, and they need your serious attention to get this mess under control.

Thank you.

GARRICK: Susan Lynch?

LYNCH: My name is Susan Lynch. I'm the Administrator of Technical Programs for the State Nuclear Waste Office, and I'd like to give the State's welcome to the new Board members. And, we hope you are as open minded, independent and unbiased as previous members have been, and current members can be.

I have a question--actually, I want to take issue with something that Margaret said this morning when she talked about we need Yucca Mountain because we will be moving 70,000 metric tons to a secure location. What keeps being failed to be mentioned is that even when Yucca Mountain is full, you're still going to have nuclear waste all over the country. It's still going to be scattered all over the place, because reactors are still operating. So, Yucca Mountain will be just adding one more spot to all these other spots. We're going to have a leopard pretty soon.

And, one question that I had hoped that the Board would ask, and I don't think they asked it directly, is that I would like a best guesstimate from Margaret as to when DOE is going to recertify their LSN, and if the TSPA-LA is going to be included in their document data base?

(Pause.)

So, you don't have an answer, is that what--

CHU: We're working on it right now.

LYNCH: Well, I understand that, but surely you have some type of target you're aiming for, since you still plan to apparently do the license application at the end of December.

GARRICK: If you make a comment, we have to use the microphone, Margaret.

CHU: Margaret Chu, DOE.

I really can't give you a specific date. This is exactly what we're working on right now. And, as soon as I have a date, we'll let everybody know. And, you know, when the--the LSN is a continuing process. So, there's an initial certification, and then eventually, when we submit a license application, everything needs to go in. So, that's really by the regulation requirement.

LYNCH: I think that's a little different from what the LSN administrator says, but I won't go there.

I do have a question for Bob Andrews. On Page 85 of his presentation, it talks about the corrosion data, the five year weight loss data and temperature dependence. Is that data from tests that were done in J-13 water, or have they been done in pore water, or is it a combination?

ANDREWS: Yes, those tests are in J-13 like waters, synthetic J-13 water, not J-13 water per se, over a range of different chemistries, to evaluate chemistry effects, if any, on general corrosion rates.

LYNCH: Okay, thank you. I'm sorry I'm having to ask all these questions of the presenters. But, since we don't get a chance to ask questions during the meeting, I sort of had to save everything up.

And, for Mick Apted, just a couple of things. You kept talking about the doses below the natural background level, and to the State of Nevada, the people that actually live out here, that's sort of meaningless, because the dose that will be received is added onto the background level. It is not substituted for, so you are getting a higher dose than your background level, no matter how low it may be, you're still getting a higher dose.

And, you showed tests in the C-22 and Basalt, and I'm wondering if that was a fresh sample of C-22 straight out of the processing, or if you did any tests that were on any type of corroded C-22, because unless the dike is going to intrude the repository right after it's in place, everything is in place, then you're going to have corrosion at least in some places.

APTED: Well, it's a fair point. I mean, these tests have just started in the last several months. So, the point you make about looking at something that's a little more advanced or aged, or something like that, would be a very sensible way to go in terms of that type of concern.

LYNCH: Okay. And, the other thing, you might think about that, too, with the dike impacted waste package, because, granted, a clean one or a new one might withstand it, but given the timing, if it hits one that has some cracking in it, then there's a much better possibility it's going to release radionuclides.

So, I thank you for letting me make this presentation, and again, welcome to the new Board members.

GARRICK: Thank you very much. It's very important that the public take advantage of this opportunity to express themselves. The Board is extremely interested in hearing from people, especially people that are local and will be affected by the activities associated with the project. So, we welcome your comments, and we encourage you to participate as much as you can.

Are there any other matters of questions or business that the Board wishes to take up at this time, or the Staff?

(No response.)

GARRICK: Any announcements, any activities that we ought to hear about? We have done a remarkable job. We've been through a long day, a lot of presentations, extremely valuable information, and we're within three or four minutes of our schedule. So, congratulations, and we're adjourned.

(Whereupon, the meeting was adjourned.)