UNITED STATES

NUCLEAR WASTE TECHNICAL REVIEW BOARD

BOARD MEETING

Wednesday, November 9, 2005

Renaissance Las Vegas Hotel
Las Vegas, Nevada

BOARD MEMBERS PRESENT

Dr. Mark Abkowitz
Dr. William Howard Arnold
Dr. Thure Cerling
Dr. David Duquette
Dr. B. John Garrick, Chair, NWTRB
Dr. George Hornberger
Dr. Andrew Kadak
Dr. Ronald Latanision
Dr. Ali Mosleh
Dr. Henry Petroski

SENIOR PROFESSIONAL STAFF

Dr. Carlos A.W. Di Bella
Dr. David Diodato
Dr. Daniel Fehringer
Dr. Dan Metlay
Dr. John Pye

CONSULTANTS

William Murphy
Victor Gilinsky

NWTRB STAFF

Dr. William Barnard, Executive Director
Karyn Severson, Director, External Affairs
Joyce Dory, Director of Administration
Linda Coultry, Program Support Specialist
Devonya Barnes,Office Assistant

I N D E X

PAGE NO.

1. What are the key data and assumptions in TSM (e.g. processing time for preparing and unloading casks at Yucca Mountain? What are the sources of these data and assumptions? How realistic are these likely to be?

2. What are the key conclusions from the scenarios analyzed to date?

3. Are there any obvious constraints or "choke points" in the waste management system? If so, how does the program intend to mitigate or resolve these problems?

4. What aspects of thermal management are incorporated into the TSM? How much an influence does the project's thermal management strategy affect the performance of the waste management system?

5. To what extent have the conclusions from TSM studies influenced design of the system?

1. What does the DOE consider to be an appropriate level of realism/conservatism in the TSPA? What is the basis for this approach? To what extent is it determined by EPA/NRC regulations or guidelines? If so, what are the regulations or guidelines?

2. Which assumptions (models and data) are the most conservative, i.e. are the farthest removed from realistic assumptions? Why were they used? Which assumptions have the most potential for skewing the TSPA results to the larger dose rates or earlier times? Why were they used?

I N D E X
(Continued)

P R O C E E D I N G S

(8:05 a.m.)

GARRICK: Take your seats, please.

In spite of one absenteeism yesterday, I thought we had a pretty good day. The Board heard a number of presentations, saw some new data, and had quite a bit to think about as far as our evaluation of it and its impact on future meetings. Of course, any comments I make now about what happened yesterday are my own comments and not representative of the Board, but I do believe that we heard some very valuable information. I thought the discussion about the standards by Forinash and Gilinsky were very constructive and helpful.

I'm always amused by some of the issues that come up, one of the issues being this business about means versus medians and I've never quite understood why that's such a debate. It seems that if you really are presenting and assessing standards on the basis of central tendency parameters and those central tendency parameters come from distributions, the central tendency parameters being medians and means, that why not use the distribution? That is a personal opinion, of course. We often talk about the fact that good decisions are based on good information and complete information and certainly I'm of the opinion that people can handle probability curves and distributions represent more information than any subset or subdivision of it. So, I'm always a little amused at those discussions.

I thought the discussion about the OCRWM program was very valuable and brought us up to date on what's going on. I guess, a walk away message I had there that concerns me a little bit is the lack of focus that could be created by the new ideas and concepts and critical decision analyses that are now going on. It seems that it's just too easy that when the going gets tough on a project that you do something else. And, I sure hope that's not what we see here. That is to say that we see a loss of focus on addressing and solving the issues associated with getting a repository.

The science program, I thought the Board has always expressed a very strong interest and support for the science and technology program and other science programs that tend to provide support information, data, and evidence for the case for Yucca Mountain. I'm always looking for a little more science work in the specific area of radionuclide transport and mobilization. The work on the source term is certainly in that direction and it would certainly be constructive to see a little more direct evidence of a better understanding of radionuclide transport specifically in nuclides in the unsaturated and saturated zones. We know there's some things going on in that regard, but we also learned from the program, as we have learned many times, that groundwater movement is not necessarily a good surrogate of radionuclide transport and getting a much better handle on what really happens to the things that matter is something the Board continues to probe and look for.

There was no question that a lot of new information, a lot of new data was presented with respect to the drip shield and some with respect to localized corrosion. And, there's no question either--I think, you've determined from the Board's questions--that this is going to take a lot of probing and certainly as to how we're going to probe that and how we're going to examine the supporting evidence will be something we'll be discussing in the next day and a half here at our business meetings. But, the issues having to do with corrosion are still very much an open issue. The issues having to do with the drip shield and its long life are still very much an open issue that we want to get a better handle on and, fortunately, we're going to hear more about the drip shield issue today from the consultants to the State of Nevada.

I do want to remind everybody that we will have another opportunity for public to make comments and this will happen at the end of the meeting. But, as we did yesterday, you're welcome to make comments or questions available as the day progresses or as the half-day progresses and give those to the staff at the back of the room and we'll be sure to address them during the question/answer session. And, of course, the public can submit written comments at any time and these comments can become a part of the record.

All right. I'd like to now move into today's agenda. We're going to cover the total system model, conservatisms in performance assessment, and the State of Nevada's perspective with respect to the tunnel stability issues. And, I'm going to ask Board Member Dr. Mark Abkowitz to lead the discussion on the total system model, and following the break, I'm going to ask Ali Mosleh and George Hornberger to lead the discussion on conservatisms in performance assessment.

ABKOWITZ: Thank you, John. Good morning, everybody.

Dr. Duquette, my good friend and distinguished colleague, yesterday alluded to running a slightly late meeting, but pointed out that there was an anonymous Board member who has a history of running much later meetings than that, that being myself. So, this morning, the Board has wisely given me just one presentation to facilitate with the hope that maybe they can teach an old dog new tricks.

In any event, this morning we're going to be hearing from Chris Kouts from DOE on the total system model. And, the Board has been interested for quite some time in terms of the waste management system and how the Department of Energy was planning that system and the interactive effects that go on in trying to make a complex system like that work.

In the Board's opinion, there are four different regimes that need to interconnect seamlessly for this to work well; namely, waste acceptance, transportation, processing and handling at the surface facility, and emplacement in the repository and to work through that and maintain the appropriate level of safety, security, and through-put is a daunting task. So, for several years now the Board has been on the record as recommending a systems approach to this. We've gotten a glimpse of the Department of Energy's desire to move in that direction, I think, initially about 18 months or so ago from Chris Kouts when he talked about a total system model that was being developed with the idea of having a tool that could represent a day in the life of a waste shipment with an eye towards being able to fully represent all the different events and interactions and impacts from operating a system of that scale.

As part of the fact-finding visits that Dr. Garrick referred to over the last nine months or so, the Board has had an opportunity to visit the developers of the total system model down in Oak Ridge and then had a subsequent presentation by that same group out in Las Vegas. We were very pleased with the quality of the work that has been undertaken. It is a very complicated model to the extent that it represents every different fuel element, but it's a very sophisticated and accurate representation to the extent that the simulation at that level was able to look at a variety of different assumptions about waste acceptance, a variety of different assumptions about transportation, and a variety of different assumptions at the surface facility, and the emplacement process. So, we see this tool as being extremely valuable in the path forward for the Department of Energy as they grapple with issues about thermal management, issues about casks, both designs and modes, issues about route, issues about surface facility design, aging tab, and so forth. So, we are very encouraged by the availability of this tool. We believe and hope that the Department of Energy will make it a mainstream decision support tool in their tool boxes as they go through the system planning process. And, we thought it was important at our next public meeting, being this one, to give the developers of that tool an opportunity to present, at least at a NAPA level what it's designed to do and also present the kind of output that are possible so that we all have a better understanding of what the capability is here.

Presenting today for the Department of Energy will be Chris Kouts. I imagine just about everyone in this room knows Chris either in his current capacity or various capacities he's served over the last 20 years in the OCRWM program. Presently, he's the director of the OCRWM office of systems analyses and strategy development and, as I mentioned before, they are the host of the TSM model.

Chris?

KOUTS: Thank you, Dr. Abkowitz. It's nice to be actually out of Washington and being able to speak about the total systems model. I was unable to attend the two briefings that certain Board members received in Oak Ridge and here in Las Vegas and it's a pleasure to be out of Washington and be here before you to talk about, first of all, our systems integration approach and a little bit about our total systems model.

I guess, when I last briefed you in February, we talked a little bit about the systems engineering approach that the Department was taking in looking at the overall system. I'm going to review that a little bit for you today. In addition to that, I'll give you an overview of the total systems model. This would be kind of a high-level view of it. We're not going to get into the details, although I have very capable staff and contractor support here to answer any detailed questions that you might have. And, we'll also be addressing some of the questions that were announced prior to the meeting in relation to the total systems model regarding key assumptions, key insights, constraints and choke points in the system, how it deals with thermal management, how we're using the TSM, and then hopefully I'll make some summary remarks that will be interesting to you.

So, if we can move on to the next slide? As I mentioned back in February, the program continues to develop an integrated approach to try to deal with the regulatory requirements under which we have to operate. First and foremost, that's 10 CFR Part 63 which are the repository disposal regulations that cover not only the underground, but also the service operations at the repository. In addition to that, we have to deal with our relationship with the utilities, the standard contract, and in addition, we also have to deal with 10 CFR Part 71 which are the movement of materials, radioactive waste materials and new controlled quantities cross-country. Most of you understand the next bullet that we have there. This program has a variety of challenges from resources, institutional interfaces, and so forth. And, to the extent that our modelers can look at cross-cutting issues that help us evaluate the program in such a dynamic environment, I think this tool can be very helpful.

Next slide, please? Again, reviewing what I briefed you on in February, we did take a systems engineering approach to implementation of the program and this has to do with the flow-down of requirements. There is an apparent requirements document in the upper box there. It's got a long name, but it's basically owned by the director of the program. I manage that document for the director. The next level of documents are what we call Level 2 documents that belong to the program elements. On the left, you have the Yucca Mountain requirements document, in the center the waste acceptance system requirement document which is what I own myself. Then, Gary Lanthrum of our transportation program owns the requirements that he needs that help define further the parent requirements that he's given me in the upper box. Underneath that are the interface control documents. Again, those are things that I control and I developed within the system; getting the system elements to work with each other, did the dynamic interfaces so we can document them and understand how we're going to implement the system.

So, if we can move right along to the next slide? Now, I'd like to talk a little bit about the total systems model and what it does for us. It basically gives us the capability to look at linkages, interactions, synergies between the different elements to understand how those elements interact with each other as the system is operating, and it gives us the capability to see whether or not the facilities that we're designing, the transportation capabilities can meet our baseline performance parameters that are in our requirements document. It also gives us the flexibility to look at alternatives to the implementation of the system as we see it, potentially give us some insight as to what system solutions might exist in order to deal with meeting our baseline, and, of course, if the program or policy impacts that affect the program, to the extent that they can be modeled, we can also look at those.

If we could move to the next slide? This is what I would basically summarize as inputs to the model. We get a tremendous amount of information from the standpoint of spent fuel characteristics that exist today at the reactor sites and ones that we expect to see in the future in terms of the burnup and age of those materials, what the heat will be at any specific year. The same thing is true for defense high-level waste or DOE high-level waste that's going to be produced and is being produced around the complex. We understand what the utilities had out at their sites. We know the technologies that they have. We also understand the operations that have to essentially be implemented at utility sites in order to load the casks and we're going to be providing them.

From a transportation standpoint, we modeled the routes that are publicly available. The ones that we're using right now, I'll get to in a little while which are basically out of our Final Environmental Impact Statement that we published a few years ago. Cask capabilities, those are all inputs to the model. In other words, how much the casks can actually move in any one shipment which is a very controlling factor in terms of a lot of outputs. The type of fleet we're going to have, how much truck, how much rail, that kind of information is all input.

And, of course, the repository operation, how the surface facilities operate, what the capabilities of those facilities are, we get down into the details of that and try to basically for the purposes of the model abstract it upward, if you will, similar to the TSPA process so that the model can run in a real time fashion.

So, I think the take back from this slide is basically the information that goes into the model comes from the individual elements of the program; waste acceptance, transportation, and repository. We get that information, we try to understand it, and try to get it into the model in a manner that is representative of what we're currently planning as we can.

The next slide, more or less, gives you a sense of what outputs come from the model. We get a tremendous amount of data out of the model when it makes a run for a 70,000 ton case. Typically, it will be just unbelievable amounts of information that you can delve into to watch waste as it travels through the system, how it travels through the system, how long it takes at any one process step, whether or not spent nuclear fuel has been aging, how long it was in aging, when it was actually put underground, and so forth to meet our requirements.

So, the diagram on the right indicates that basically the model as it's constructed gives us the understanding, if you will, as to how the elements interact with each other and how certain requirements in the system can flow back, certain requirements in the repository then flow back to waste acceptance, and how also waste acceptance propagates to this and then affects how the system operates.

So, if we can move to the next slide? This is what I would refer to as the geek slide for those of you who are into model architecture. I won't try to go through it in a great deal of detail other than to say that the platform that we selected for this model called SimCAD. It's a trademark software. It's something that we felt was an excellent choice for our purposes. It's something that's been used in manufacturing processes, refinery processes, basically airport queuing, hospital queuing. It essentially is an object driven model that allows you to follow an object through it. An object will move from one step to the next depending on the trigger that that object needs. For instance, if a reactor is waiting for a cask, the reactor will call for the cask and the type of cask that that reactor needs. And, that's the kind of trigger that will move the model. Then, once the cask is filled, then it has to move through the transportation system. It gets to the repository and it has to go through the different process steps. And, I'll go through this in some more detail in some later slides.

Again, I'd like to reiterate the advantage of the models. That it does give us a tremendous amount of data that we can go back and mine and research and understand how the model is telling us how the system will operate. It also has the advantage of having a graphical user interface so you can actually watch the model as it operates and see if there are any choke points or problems associated with the implementation of the systems. So, from that standpoint, it's a very useful tool to help us understand how that system might be implemented.

We can move to the next slide. This is kind of a high-level view of the graphical user interface. This gives you a sense of transportation, waste acceptance, and the repository modules. Each of those boxes, each of those little items, if you click on it with the model, you can pull up the sub-model. It's actually a model within models and a variety of different models that flow up into upper architecture. But, you can delve down to look at a specific sub-model. If you want to look at a specific facility and see how that facility is operating, if you want to see a component of a transportation system is operating, it gives you the flexibility and the capability in order to do that and I'll show you that on succeeding slides.

Let's go to the next slide. This is a sense of just a segment of part of the transportation system. This is the southeastern section of the country. You can see that there's a variety of different types of transportation modes here. We've got barge, we've got heavy haul. We basically tried to model exactly what we had in the FEIS. This is really not new information, but it helps us understand how the transportation system will be implemented. In addition, we can track how many shipments will go through Atlanta or any other node that we have within the system and that's very valuable from just understanding as we move forward how, when we start to deal with Section 180-C, emergency response requirements, we can get a sense of how many shipments one area of the country might see as opposed to another area and we can make a determination about what kind of resources may need to go to those different areas of the country.

Moving on to the next model--this is a group of models, I should say. This is a depiction of the different processes that we have within the repository program, surface facilities. I think the real advantage of the model here is that if you want to shut off a facility, you can shut it off. Take, for instance, the dry transfer facility is down and you can see how the system will react if, all of a sudden, we lose our bare fuel handling capability or our production bare fuel handling capability. Or if you wanted to see how the system would react if our canister handling facility went off-line for some reason, you can also see that. In addition, because we have sub-models that we can add, basically within the architecture of the model, we can add more canister handling facilities if we're going to more of a canistered approach and we can see basically the kind of facilities we'd need to meet our rate. So, again, it's a very flexible model. It also allows us to watch on a real time basis how the system is being implemented--is operating, I should say.

Next slide. I'd like to get now to the specific questions that the Board asked prior to the meeting and I'll try to touch on each of those topics. And, I'm sure if you have any questions, more information, or if you want to stop me as I'm going through, you can feel free to do that.

Let's go the first slide. I think the first question was and I'll read it to you, "What are the key data and assumptions in TSM (e.g. processing time for preparing and unloading casks at Yucca Mountain? What are the sources of these data and assumptions? How realistic are these likely to be?"

I essentially covered this in my introduction, but

I'd like to reiterate the fact that we go to the people who are actually designing the facilities, implementing the facilities, and get the data directly from them. Now, we don't make up the information. We go to the individual components of the program, sit down with them, and try to get information so we can figure out how to make the model work. We also have a very strict configuration control plan on this model. We know the configuration of the system that we're running. We document that, and if we're going to make changes to that, we go through a change control process so we understand from one scenario to the next what changes we've made to the system and to the model as we're evaluating it. So, I think that's critical in terms of understanding the different options and implementation options of the system and it's something that we're going to with as much rigor as one can imagine with this area.

In terms of the issue of realism, I think that's a subjective term. I think we do ask questions to the people within the program regarding the assumptions that we're using and information that we're taking back. I think the information is as good as we can get it and will get better as we move forward into the future and we learn more about the systems. So, as we get better information, more information, we'll update the model and update the inputs to make sure that it's tracking the system as much as and as closely as we can.

Next slide. This basically gives you a sense of how we take the information from the repository modelers or the repository designers, if you will. The simulations that the repository designers use--and they use similar software to what we use--they're down to the 10 to the 30 minute process step within each of their facilities. Our TSM or our total systems model basically looks at eight hour increments so that we will take the 10 to 30 minute steps and we'll roll that up to an eight hour step, if you will, of operations within that facility at a higher level so we can basically make the model operate. But, we look at eight hour time steps and we go for eight hours from initial operations through the 30 or 40 years that it takes to get all the waste into the system. And, that's another reason why we have so much data that comes out of this. So, we are down to the eight hour level, and in many cases of the facilities there, at the 10 to 30 minute level done in their simulations.

If we can move on to the next slide, I, more or less, already covered this, but the information that we take from the transportation component of the system basically is reflected by those routes that were in the FEIS. As those routes change as we identify routes in the future, of course, we'll update the model and make sure that it's consistent with that. But, at the current time, we're looking at the rail and the truck routing that was in the FEIS that was published several years ago. And, of course, we'll have strong configuration control on that, and as we change those routes as decisions are made and as we work with state and local governments, we'll update the model and again understand exactly how the transportation system is operating.

The same thing is true with input that we get from the utility sector. We went through kind of an informal survey with the industry last year. The facility interfaced datasets that--well, when we asked them to update their information at their sites, we understood what kind of crane capacities they have, what kind of capability they have to handle various types of casks on their site, and we took that data and that's the data that we're currently using in our model. And, as we get more information from utilities in the future and as their capabilities on their sites change, we'll make sure that that information is also input to the model.

Now, in terms of key insights that the model can provide us, I just want to give you kind of a theoretical example. If you look at the blue line here, those are our system requirements that indicate the ramp-up rates. In our first year of operation, we're projecting that we would want to have a 400 ton capability to move material through the system ramping up to 3,000 tons in the fifth year. That's what the blue line indicates. And, the red line indicates based on a theoretical analysis of the capabilities of the facilities that we currently have designed, you can see little gaps between the requirements and the actual baseline requirement which is depicted on the right graph over there.

And, the first valley is basically a sense of if you look at the facilities that we currently have which, of course, may change based on our canister decision, the first facility we had available was the FHF, the fuel handling facility. One of the things the model tell us is that it takes just about as much time to process a truck cask as it does a rail cask. And, if we have a variety of truck casks in the system, our ability to process that until the DTF comes on line is limited. So, we have a little valley there which indicates what we call a valley curve which indicates that our ability to process those materials through is limited because of the facilities that we have. And, the larger valley curve on the right, assuming that the Department decided to take the canisters from utilities that currently exist, our ability to cut them open and our ability to repackage them is basically limited in the DTF facilities that we design. What you see there basically indicates that we would have a deficit, if you will, in terms of our acceptance capabilities since we were taking those toward the end of the operational life of the repository in the 25 to the 35 year time frame. Now, this is information that gives us an understanding, if you will, that if we want to reduce that valley curve and maintain our acceptance capabilities and our processing capabilities that we may have to add additional capability in order to deal with those unless we want to have that deficit out there. So, these are the kinds of insights that the model can provide us and basically inform us as we implement the system.

Next slide, please? I know thermal behavior is something that the Board is interested in and the model does have the capability to track the thermal output, if you will, of an assembly as it leaves the reactor and a group of assemblies, if you will, all the way through the system. And, also, when you set a constraint about 11.8 kilowatts per waste package, it also allows us to see how we need that constraint and how much aging we have to do on site and so forth. So, basically, the model gives us the capability to see exactly what a thermal constraint might be here at the reactor sites or at the repository and give us information, if you will, as to how well we're meeting that.

And, that's what the next slide gets to. Well, this is one of those slides, I should say. The last slide is the one I was talking about, but let me talk about this one. In terms of how much aging we'll need on site, it gives us an understanding, if you will, of how much we'll need and over what time period we'll need. And, in this scenario, it's roughly about the 21,000 metric ton case which is basically what we've been designing to all along. So, it does provide us insight as to whether or not we're meeting the 21,000 case, if you will, that we've been analyzing in the past and in this scenario, it does.

And, the last slide--next to last, I should say--again the output of the model gives us so much information. We can see how well we're meeting the--this is a PWR cumulative average case for each of the different packages that we process over a 35 year period. We can see you can thermally map each one of these so you understand whether you're meeting the 11.8 or not and you can look at what the mean is of those that we're processing in any one year. So, it's a very powerful tool in that case to give us insight as to whether or not we're meeting our thermal goals.

And, with that, what I'd like to do is to just make a couple of summary comments that we believe it's a very useful tool, we're going to keep working on it, and we've got to keep working on it to keep it updated to our latest program assumptions and our latest configurations, if you will. And, we look forward to the fact that this will, hopefully, help us in the future understand how we can make the system better and how we can operate it better.

And, I'd be happy to answer any questions.

ABKOWITZ: Thank you, Chris.

Board members, Andy?

KADAK: Yeah, Chris, I think the program is really very, very good and hopefully will be used in the future. I have some questions about assumptions though and I urge you to contact the stakeholders directly to get the data. Based on our, you know, evaluations, it appears that some of the assumptions that you've made aren't necessarily appropriate for what the reality is in terms of the field. And, in particular, the availability of spent fuel currently in pools in terms of its heat load and whether or not, you know, you can have the utility thermally blend in accordance to your standards. And this is, I think, a critical issue that is hopefully now being addressed when you look at the canister program. Your comment on that?

KOUTS: Yeah, I think whenever you want to dialogue with the utilities about meeting our thermal needs, if you will, assuming we understand what they are and assuming we know exactly what we want, it always comes back to the issue about, okay, when are you coming to my site? Because it's very temporal. In other words, what's in the pools today is not going to be what's in the pool 10 years from now because they're going to make their own decisions based on what they need to do to put materials for dry storage. So, the discussions and the projections that we do are our assumptions based on how the utilities will manage their fuel. We do make projections of that. But, again, at getting back to every time we do dialogue with the utilities and we do talk to them, it always comes back to, okay, you let us know when and then we can tell you what we can do to meet your goals. That's a very important key question that you have to answer for them before you can get real time information from them that may be helpful.

KADAK: I guess, if it's such an important question then I think you need to do that now to validate assumptions not only in what's in the pool, but also when you think about designing a cask system to handle off-normal fuel, small or larger, you may be making an assumption that isn't also valid because the utility probably--you know, if you're going to go to a truck or rail system, those assumptions are critical and I think that input is very important to the policy makers at DOE regarding this program. So, I strongly encourage major interaction not only with the utilities, but the truck and the rail and also the logistics providers because it can dramatically change what you're designing.

KOUTS: That's a good point and I do want to indicate that I do think the utilities will work with us and try to meet our needs. I think it's to everyone's advantage. And, when we have those discussions, I'm sure you'll be--I think, we'll be very pleased with how they'll react to our needs.

ABKOWITZ: David?

DUQUETTE: Duquette, Board. Chris, it looks like the program is very flexible and we've heard some discussion about a change in possible procedure that would involve containerizing the fuel at the site and then just basically sliding it into the waste package at the facility. I'm sure the system can handle that just fine. Have you begun those analyses?

KOUTS: Yes, we have.

DUQUETTE: Will you be able to share the results of that with us at some point?

KOUTS: Sure, I think we'd be happy to do that. I think that the model doesn't tell us--it doesn't give us great insights and, hopefully, it won't because it should be intuitively obvious what the results of the model are. And, let me just give you an example. What the model will tell you is that the larger the package that you move to the system, the more effective and efficient the system is primarily from the standpoint as it's fewer shipments, it's lower dose of utility since they've been in low operation in the fuel operations, it's fewer packages that we're handling at the repository. It's those kinds of things that the model can put out insight to. In terms of heat load, what it will tell you is if you go above 11.8, there are certain advantages to going above 11.8. There's more fuel available to meet that capability or that restraint at the sites than at 11.8. Also, it potentially reduces the amount of aging that you have at the repository in order to meet the thermal goals. So, I think we're looking at parametric analyses and, yes, I think we're more in position to share that information and we'll certainly be happy to sit down and share that with the Board.

DUQUETTE: I'm reasonably sure it's going to change those valleys considerably because, at least, one of your valleys had to do with cutting open the containers and repackaging at the sites. I think that's going to change for sure.

KOUTS: Well, that's going to be an interesting subject as we go forward and I don't want to, you know, bring lawyers into the room, but that's also a subject of litigation between the utility industry and the Department and I won't say anything about that because I was in Court two weeks ago.

DUQUETTE: Didn't mean to open that Pandora's Box.

ABKOWITZ: Thank you. John, then Henry, and then Ali.

GARRICK: Chris, let's go to Slide 11. When you presented this slide, you indicated that the model had the capability to shut down any of these steps in the process. Have you made any attempt to correlate the shutdown scenarios with actual operating conditions and actual insights learned from the safety analysis at the surface facilities?

KOUTS: Not as of yet. I think that's something that's on the table for us to do as we move forward, but that's--as we indicated, the model has the capability for doing that. We haven't actually sat down and looked at those kinds of scenarios as of yet. And, with the configuration of the system changing, this is what I would consider to be OBE, if you will, this configuration is OBE, but as we develop new configurations, I think we're going to have to get into the kind of issues that you're referring to.

GARRICK: Yeah, this is very relevant to the question about bottlenecks or choke points or what have you and I'm especially interested in upset conditions.

KOUTS: Right. We have the capability to do that also; not here, but also in the transportation area. If there's a segment of rail line that's down for maintenance or something, we can watch how the model would route the shipments around to a different, you know--

GARRICK: I think it would be very valuable in designing any kind of a recovery plan or emergency response or what have you.

KOUTS: Agreed.

ABKOWITZ: Okay. Apparently, there's telepathy on this side of the table. Henry's question and John's question were one and the same. So, we'll move to Ali.

MOSLEH: Mosleh, Board. This, of course, has been an extremely valuable tool. I think we recognize that and I'm very excited about, you know, the potential that you have. So, my question is mostly on the capabilities of the tool you're utilizing. To follow up on John's question, do you envision this to be at some point a means to actually do a probabilistic scenario analysis?

KOUTS: Yes.

MOSLEH: Okay. And, is it also a tool for optimizing? I know that you can run sensitivity parametrics, but you can also optimize?

KOUTS: Absolutely. Absolutely. And, as the system becomes more defined, I think that that's what we'll be looking at and I think we want to first conceptualize a system that will meet all the uncertainties and then you being to look at, okay, given the uncertainties, how do you focus down on a deployment that will deal with the outliers, but will be as efficient as you can possibly make it. So, the simple answer to your question is yes, but the model does have the capability of doing probabilistic inputs, if you will, and I think that will be an excellent tool as we move forward to help optimize our system.

ABKOWITZ: Howard?

ARNOLD: Arnold, Board. I guess, my question is related to Ali's. Looking at your model here, I'm asking where you think you stand. Do have further model development efforts needed or are you basically in a mode of optimizing or reacting, as the case may be, to program decisions made by the project office?

KOUTS: Well, I think it's a little bit of both. I think what we're seeing now within the program is that people want to understand can the model look at this, can the model give us a sense of how the system would operate under this scenario? So, I think, we're going to be helping the people who are going to be making decisions about the system understand how the system will operate with "what-ifs", if you will. So, in addition to that, after we come up with a configuration, as I mentioned in relation to the last question, it's going to give us the opportunity to do sensitivity studies off what we think is going to be the right configuration for the system and understand its flexibility, if you will, to deal with the out of bounds of the uncertainty that we're going to have to deal with.

And, let me give you an example of uncertainties. I know that this canister decision is something that the Board is very much interested in and we're looking hard within the program to figure out the best way to implement it. We want to try to maximize the amount of canister materials that we're going to be handling at the repository, but the amount of canister material will be dependent on a lot of things. It will be dependant on the size of the cans that we develop and the capabilities at the reactor sites, the willingness of the utilities to participate in this exercise. Remember, we've got a contract. We can't dictate to the utilities; we have a contract. We have two signatures to that contract, the U.S. Government and the contract holder. So, the uncertainties in terms of the out of bounds, the best we can do and maybe the uncertainty about how much bare fuel handling we'll have in the system is something that we're going to have to work on and the model will give us insights as to the kinds of facilities that we'll need on site to deal with, shall we say, the bounds of what we feel we can implement from a canistered approach.

ABKOWITZ: Thure?

CERLING: Cerling, Board. This is a long way out far from where I spent a lot of my time thinking. So, I'm just wondering how you interact with all of the elements that are non-DOE and, in particular, do you go out to talk to the railroad, the utilities, and the manufacturers and get their input or do you somehow have a system where those entities can all interact with each other and where part of the playing field is just one of the many plans?

KOUTS: Okay. Let's take a piece of that at a time. Gary Lanthrum is implementing the transportation system. So, Gary is really doing the implementation of that. He's the one that's talking to the railroads. He's the one that's looking at how best to implement that. So, he would be our process source of information. He's within the program devoted to those responsible elements and that information. Now, if it had to do with the reactors, we have mechanisms to get information should we need it from the utilities also and we do have interactions with them.

So, the simple answer to your question is there are interactions, I think, at every level; at the working level and those elements that we're trying to deploy, those pieces, the people at the repository working on their designs, but there's a lot of cross-cutting information that we share and there's a lot of communication in the program in order to try to implement the approach. So, that's the best way I can answer your question. We don't have a meeting like this and get 500 people in a room, some people from the transportation industry, utility industry, and so forth. In most cases, that isn't productive, but we do try to find the best available source for the information and we try to work through the program to the extent that we can to get that information.

ABKOWITZ: Dr. Duquette?

DUQUETTE: Duquette, Board. I see your program currently, this systems analysis as you're currently using it as a strategic plan on handling, moving stuff into the facility. This has to do with John Garrick's question. Do you see this as a practical tool that can be used on a day-to-day basis assuming, for example, an upset condition such as a derailment or a fire in a dry transfer facility that will hold up waste and so on and so forth? Do you see it a program that can interact with the program on real time basis while it's in operation? For example, let's hold up that shipment at Point A because something is happening at Point C?

KOUTS: It certainly has the capability to do that. I think that that gets down to more than optimization approach about how the system will react to different situations. And, again, we had a system deployed and now that system is going to be changing. We're going to get that configuration done first and understand how it operates given the uncertainties. Then, I think the next step will be to do exactly what you're talking about which is to basically look at "what-if" scenarios and how the system will react to the events and let's you see in the end the loss of capability at various points within the system. The same thing as if reactors are unavailable, you know, what other reactors can we go to at a certain point in time. I mean, all those things have to be looked at.

DUQUETTE: I had more in mind something like an immediate response type thing where someone is monitoring this thing on basically a day-to-day basis and saying I know exactly where everything is and what's happening and what I'm going to do if something goes wrong somewhere in the system.

KOUTS: I understand and that's something that--given where we are today, I think it's something we need to do, but we haven't done it up to this point.

DUQUETTE: Sure, thank you.

ABKOWITZ: Andy?

KADAK: Kadak, Board. I'd like to push back on the comment about a lot of communications with the stakeholders. Our experience and our conversations with those same stakeholders, including the trucking companies, the railroads, the utilities indicates that you've had almost no communication with these stakeholders. And, I think, that has effected the design of the facilities that are displayed here and are a serious problem. And, I think the tool that you're developing is a great vehicle by which to engage in serious discussions with these stakeholders which is what I encouraged you to do earlier. But, the problem apparently is what you mentioned earlier, legal questions, legal disputes, Court cases. I would urge the Department of Energy and the utilities to put that behind them and help design the proper facilities for radioactive waste management because, as we've observed them, they're not even close to being optimized or even real.

KOUTS: Okay. I'll respond to that in a couple of manners. First of all, in terms of the fuel that the utilities have on site and the characteristics of those fuels, we do do surveys with the utility industry. The RW-859 form that we go onto, we get a good response from them and these are the people who are actually managing the fuel. So, we take that information and that's the type of information that we have in the model. These are forms that are filled out by the people who are doing the fuel management at utilities. When we talk about communications, it's not necessarily oral. It's also documented information that we get from them.

In terms of the lawsuits, the lawsuits are a fact of life. And, when there are issues associated with those lawsuits--and I think the concern of the Justice Department is that we've got 60 outstanding lawsuits. We've only litigated five. Up until this point, we've only had five trials. There's 16 more trials that will be laid on in succeeding years. I think that we can go to the utilities and ask for specific information if we need it. If it gets in an area that's affected by the litigation, then we have to be very careful about how we do that.

But, you know, I've talked to--and you might remember the meeting that we had back like in February where point blank we asked the individuals present--it was Rick Craun, it was Gary Lanthrum, and myself--about is there any information that we feel that we need--and that was at that point in time--that we didn't have and we would--that we couldn't obtain from the industry or from any source and I think the unanimous view would have been, that group of people, was no. That's not say that as we move forward that new information needs may become available, but I can assure you that as we need that information, we'll find a way to get it. Your comment is well-taken. But, we have to work under the environment that we're in and within those constraints and we're going to do the best we can under those constraints.

KADAK: My comment wasn't so much addressed to you, but to the program managers and the lawyers.

KOUTS: Okay.

ABKOWITZ: Ron?

LATANISION: Latanision, Board. On the face of it, this sounds very much like nerve central for this whole operation in terms of tracking, optimization, etcetera. You know, I'm very impressed with how far you've come in such a short period of time. My question is what's required to go forward to meet what appears to be enormous potential for the system in terms of the operation? And, by that, I mean, fiscally, intellectually, whatever it takes to make this the optimum system from your perspective?

KOUTS: Well, I think the simple answer to your question is I think using the tool more and more and getting more people in the program to want to have it utilized and to make it as reflective of where we are at any point in time so it does provide us with that information. When we started this effort over two years ago, it was, oh, it's another model. You know, how many models we had in the past, it's not going to be very useful. But, as we got into it and as we worked very closely with the different program elements, they saw real value in it. For instance, as we started using this type of simulation technology, I think the repository wanted to use similar programs so they could actually simulate how their processes within their facilities were operating. But, this is the only tool in the program that rolls it all up and it does provide insights and, you know, my people are giving briefings to people throughout the program on a regular basis to try to show the capabilities and also show what we're finding out in terms of how the system operates. And, an even more challenging time now with the system changing and going away from this configuration to one that's going to be more of a canistered approach and we're going to be running the model a great deal, if you will, on "what-if" scenarios and bounding scenarios so we understand how the system will operate given this canistered approach.

So, I think that the missionary work that we've done over the last two years to get people involved and to get them to understand that it's a useful tool, I think, is successful and we hope to do as much of that missionary work, if you will, and get more use out of it and more utility out of it.

LATANISION: Latanision, Board. Just a followup, do you feel we can have the fiscal and intellectual resources to do this? Is it in your budget, is it in your staffing? I'm quite serious. This is very important.

KOUTS: Well, a simple way to answer that, I did before yesterday, okay? We'll have to find out how that affected the program overall and I'm sure it won't affect the program overall. My expectation is that the total systems model will certainly survive that. But, right now, I feel we have the resources that we need, we've got very capable people who developed it, and we plan on maintaining that capability and expanding it. So, the simple answer to your question is, you know, I think, we're getting to the point where I think this is going to be very helpful to the program.

LATANISION: Thank you.

ABKOWITZ: Abkowitz, Board. Chris, I can't resist asking a couple of questions myself and some of these really kind of follow up to technical and institutional questions that my colleagues have asked. But, I wanted to start off getting back to this issue of the extent to which TSM has been adopted internally as a decision support tool. Has there been any kind of, you know, statement from headquarters that basically says thou shalt accept and work with TSM or is this still the new kid on the block and there's pockets of resistance?

KOUTS: Well, no, there has not been an edict from on high that says thou shalt use TSM. And, whether I think there needs to be, I think that those kinds of methods, if you will, are interesting, but it gets down to whether people in the program really want to use it. And, I think the better way to work that is again to do the missionary work to get people involved, to get them to understand that their input is going into it, and we're getting a better understanding of how the total system operates. So, a simple answer to your question, no, there hasn't been something like that nor do I think there really needs to be.

ABKOWITZ: Okay. My followup question and comment related to that is it seems to me that this is one of those cases where if each of the different component responsibilities to the system are not willing to sit at the table, then the whole effectiveness of the tool breaks down because you need to have every player interacting. And, that really leads me to my next question. Is there any plan to have these various, I call them regimes, you used I think a different word, but are there any plans to have these folks sit down in a workshop environment or some type of environment where the tool is used as a facilitator to try to elicit the pushes and pulls that go on as decisions are being made in various places?

KOUTS: We haven't had those kinds of meetings as--we've had individual meetings with the managers, certainly, of the repository out here in ORD and with transportation and we do have regular discussions, but we haven't held meetings such as you've suggested and that may be a good way to go. I think we're looking for new concepts and better ways to integrate. But, one thing that I've learned, having been in this program as long as I have. is that if you're really going to call a meeting, you want the meeting to be a useful meeting. I remember years ago--this is just an aside, but this is when I just joined the program and someone said they were excited. Yeah, I'm excited about that meeting and then someone said I can't believe anyone is excited about another meeting in this program. But, to the extent that we can make those kinds of interactions useful and--that could be a very good suggestion. What we've seen is that in the past we were going to people to try to get information for the TSM and now people want to come to us and see how the TSM reacts and how the system will react utilizing this tool. So, I think that kind of shift has occurred and my sense is that that's only going to continue as we move forward.

ABKOWITZ: Okay. Just following along in that direction, there have been a number of sort of "what-if" scenarios that have been postulated by this group and by you, issues about different thermal loading strategies, cask design capacity, surface facility design, modal mix, waste acceptance in terms of fuel age, and even ranking in the queue, and it goes on and on and on.

KOUTS: Right.

ABKOWITZ: Have you given any thought to developing, I guess, what I would refer to as a scenario evaluation plan where you take all the different parts of the puzzle and explore different design and operating options and then come up with sort of a grand systematic scheme for all the different things you're going to test and do you think that would be a good idea?

KOUTS: We actually have done a lot of that as we've developed the model to look at this configuration. We've done a variety of different sensitivity analyses off of that. That was done in a fairly structured manner. We sat down and we wanted to understand how the system would operate given different parameters. More truck than rail or more rail and less truck than we initially anticipated, those kinds of things. So, we do try to sit down and scope out a list of sensitivity analyses that would help us understand the out of bounds to the abilities of the system and we try to do that in a structured manner. So, I don't know that we wrote a report, but we meet about that on numerous occasions to try to figure out how best to utilize the model and understand the capabilities of the system.

ABKOWITZ: Well, thank you. My final question has to do with the output metrics and how you can put them to use. We've seen a lot of sort of efficiency throughput types of measures here and I do know from prior review of the work that there are some list based measures in there in terms of doses and things of that nature. I was curious whether the model currently has or there's plans to put a cost element into it, as well, because it seems to me that some of the ways in which this could be designed and operating could have order of magnitude implications on the overall program cost.

KOUTS: It does have cost capability also.

ABKOWITZ: Okay. We have a couple of questions from Board staff. Dave Diodato?

DIODATO: Diodato, Staff. Thank you for your presentation this morning, Chris. I think that the TSM really--we've heard the comments that goes a long way towards this integrated systems level thinking the Board has long been encouraged by. And, I was encouraged in your response to Dr. Mosleh that you can run this in a probabilistic mode because my understanding of risk is that in this case, it would be like dose times probability would equal risk. And, you can optimize. You have potential for optimization. In hydrogeology, we call that the inverse solution to the problem. So, you could theoretically optimize your system based on a risk output in the future. You haven't done that as of yet though?

KOUTS: No, we haven't, but the model does have the capability to put in distributions, if you will, of various input parameters so you can look at kind of a stochastic implementation of the program. But, we haven't gotten to the point where we've implemented that. That's something we do want to do.

DIODATO: That will be interesting. Well, at this point though you have some dose numbers. So, do you have a sense of what the three or four or five different variables that contribute the most to the dose, what choices that you can make that would tend to maximize or minimize the dose exposure to the public?

KOUTS: It has to do with how many packages you're moving through the system, abundance of materials. The larger bundles that you move through the system basically are reducing dose. Certainly, if you limit aging, that reduces dose which would be intuitively obvious because you're not moving these large storage packages out to the aging facility and you have to move them in and out, plus you have to have personnel go around them and check them out every once in a while. So, the extent that you can minimize aging, that helps reduce dose. To the extent that you move larger packages through the system all the way through it, that helps reduce dose, thus operations at the utilities. And, I will say that from a dose standpoint, we don't just look at our dose, we look at also the dose that's propagated to the system at the utility sites and also, you know, through RADTRAN simulation type of analyses to, you know, dose along the transportation route.

So, the other thing, as we move forward into a canistered approach, we have looked at whether or not seal welding, if you're going to require seal welding for the canisters, that will increase dose because that means personnel at the utility sites will have to get up there and do that in a manual activity. If you can come up with some kind of a bolted closure, that would be less time we have to spend around the top of the cask and that will reduce dose. So, those are the kinds of things that the model can give us a sense of the magnitude of the differences in the dose and it gives us some insight as to some things we need to talk to the utilities about.

DIODATO: That's an important decision and it's encouraging that you have a framework to get some quantitative feedback on those decisions. Thank you.

ABKOWITZ: Carl Di Bella?

DI BELLA: The scope of my question, maybe a couple of questions, has to do with what is internal to the model and what is external to the model and what are assumptions as far as calculating the future or estimating the future of population of spent fuel pools and on-site dry storage capability also. The program is driven by a database of using the RW-59 data. How current is that data rate now that's in the program?

KOUTS: I believe the last time we did the survey was year before last and what we've tried--the type of information is what exists in the pool and what the plans are for the future, what kind of burnup, what kind of enrichment they're going to have for the different assemblies that they're going to be operating in the future. So, we try to get a projection from them as to the kinds of fuels they'll be using and again at burnup which affects heat, which affects radiation fuels, and things like that.

DI BELLA: And, do you keep--is the database in your model on an assembly by assembly basis or some sort of aggregate?

KOUTS: No, assembly by assembly basis and I should say the survey is done for us by the Energy Information Administration, EIA. They're the ones that go out and actually collect the data from the utility. So, that's a useful source of information and that gives us a lot of information about what's happening at the utility sites.

DI BELLA: And then, for future utility pool contents as a function of time you use this other input as opposed to-- what you just mentioned as opposed to attempting to simulate it yourself?

KOUTS: Well, to the extent that if we don't have specific information about a reactor, there are a lot of industry publications about where fuel management is headed, the types of fuels that they're planning to use at reactors around the country, and that also informs us, you know, for future because the fuel that we're going to be disposing of in many cases hasn't been designed yet by the fuel fabricators and by the fuel designers. So, we'll get projections from them about where the trends in the industry are, you know, 20 to 30 years from now so as we move forward we can understand what the heat capabilities will be of those assemblies when they come out of the reactor and we can model that in full scenario when we get to the distant future. But, you know, we do the best we can with the information that's out there and some of the information in the distant future, as you know, is more speculative than the ones that we get today.

DI BELLA: Thank you.

ABKOWITZ: Dan Metlay?

METLAY: Dan Metlay, Board Staff. Chris, you used the phrase sort of "intuitively obvious" several times with respect to what the model does, most recently in your response to David's question. I'm wondering if you could tell us one or two examples where the model has produced important insights that were counter intuitive?

KOUTS: I think, instead of counter intuitive, I would say more that--for instance, the model that is--ultimately, it's an adding machine and the adding machine is going to give you a lot of answers to different questions. I think the information is not so much, you know, whether or not something should be larger than something else, but the magnitude of that. For instance, as I mentioned, the dose at utility sites from a bolted to a seal welded closure, given the amount of operations, given the size of the packages, and so forth, it gives us a better understanding of the magnitude of the difference, if you will. But, it doesn't tell us--if it had come back and said that the bolted closures gives you more exposure than seal welded closures, I would have said, you know, there's something wrong here. But, I think it's useful, and from that perspective, it's to the magnitude because it does go through and crunch all the numbers and gives us a total magnitude number which can be very informative in terms of how much we're saving in terms of dose and can provide us some insight as to how hard we want to pursue something. If there's a very small difference between one parameter and another and it doesn't make very much difference, I think that's useful information, too, because in the long-run, it doesn't make that much difference.

So, that's the kind of information that I think the model can be very helpful with, but again you have to step back and say, okay, with any model is this intuitively obvious? Is it telling you something that's counter intuitive? And, I think, as we've gone through it, we haven't found anything like that, but nonetheless, as we move forward, we may and then we'll look real hard at it.

METLAY: Great, thanks, Chris.

ABKOWITZ: John Pye?

PYE: You've touched on thermal management criteria and there are two and they're both performance based, 11.8 kilowatts per waste package max and a line load of 1.45 kilowatts per meter. Do you have the specification for how you're going to achieve the 1.45 kilowatt per meter, and from a waste emplacement sequencing perspective from an operational point of view, how do you intend to keep it?

KOUTS: Okay. The way we've addressed that is we've focused more on the 11.8 kilowatts per package and our assumption has been that if we meet that, then we'll meet the 1.45 requirement. As we move forward, we may have to get more details, but that's been our underlying assumption. We care more about the average heat load or the maximum heat load in any one package than anything else. With the assumption--and again that's an assumption that we meet the heat load, the line heat load at the repository in the drifts. But, as we move forward, that might be something that we could look at. But, again, at this point in time, we're only looking at trying to make that package the way--from a recipe, if you will.

ABKOWITZ: Okay. Chris, you can tell by the number of questions and the types of questions that the Board is very interested in what this tool is able to do and the potential for it in the future. So, we thank you very much for hanging in there and answering all of our questions and we look forward to future interactions with you. It's definitely an encouraging sign that we'd like to pursue as we move forward.

We're up against a scheduled break now. We will break at this time and reconvene at 9:40.

(Whereupon, a recess was taken.)

HORNBERGER: Good morning. We're ready to reconvene. I'm George Hornberger and Ali Mosleh and I will oversee this next session.

The total systems performance assessment is truly a formidable undertaking. This is a complex modeling problem, and regardless of what weaknesses people may perceive in a TSPA, it certainly has to be seen as an amazing accomplishment that the Department has made because this really is a complicated problem. Because it's so complicated, there's a necessary blend of what we refer to as realistic modeling and bounding analyses and/or conservatisms. The Board has been concerned for some time that the use of bounding analyses and conservatisms, although obviously necessary for a complex TSPA, can mask what we anticipate scientists and engineers see as the real expected performance of the repository. We are concerned then that this masking of the anticipated performance can cloud judgments of what may or may not be important and would, therefore, ask the Department of Energy to give us an update on conservatisms in the TSPA.

We have two presenters, Abe Van Luik with DOE and Bob Andrews of BSC. Abe and Bob, I'm going to let them introduce themselves in detail. I will say that I've known both of them for some time and they certainly are the people who have a comprehensive and in-depth knowledge of TSPA. So, I'm looking forward to their presentation.

Abe?

VAN LUIK: Thank you very much, Dr. Hornberger.

My name is Abe Van Luik. I'm a senior policy advisor in the licensing office, senior policy advisor for performance assessment. And, just to give some of you who don't know me some more background, I began in performance assessment in the 1980s working with the Pacific Northwest

National Laboratory in the PASS program. For a while, I was the TRW performance assessment manager and then I moved over to DOE in 1995 and became the overseer of performance assessment from the DOE side and then moved successively up into a senior technical advisor and now the senior policy advisor. As one of my bosses when I first became the senior policy advisor reminded me--this is a man who is retired, a very smart man--but one time when I kind of disagreed with him, he said let's look at our job descriptions. You are a policy advisor, I am a policy maker. I am listening to your advice.

Okay. We need to go to the next viewgraph. What I'm going to do is talk a little bit about conservatism and the way that we're approaching it, regulatory, background, and the role of conservatism. Then, I'm going to read to you some of your own observations to us and some of our responses back to you. Bob Andrews will then step up because he is the resident expert and the contractor on the technical parts of this. And then, I'll come back and give a summary.

Next? The primary purpose of performance assessment is to demonstrate post-closure regulatory compliance. Now, we also do assessments for pre-closure, but this talk is focused on post-closure. We intend to provide a demonstration of post-closure regulatory compliance that does not underestimate dose. That is a basic guiding principle.

We do not want to underestimate those. And, we believe that this demands the application of a cautious, but reasonable approach in modeling long-term performance. We do use conservatisms both in the process-level and the abstraction-level models to simplify analyses and reduce the need for additional information.

Now, one thing that was mentioned yesterday by Dr. Garrick suggests there may be some dichotomy between showing compliance and showing understanding. And, having been part of the key technical issue resolution process and having carefully read our documentation that we are preparing to address the Yucca Mountain review plan, I am no longer seeing a dichotomy between showing compliance and showing that you understand your system because those two processes have been excruciatingly questioning of our approach, our assumptions, and everything else. And, I think some of the questions we had from the Board yesterday illustrate the kind of questions that we get routinely from the Nuclear Regulatory Commission. So, I think, they would say that in order to show compliance, you better show that you understand this system.

Next? I think that Dr. Hornberger already said this. They're inherently complex, these post-closure performance assessments. They need to address a range of uncertainties and some uncertainty is inherently irreducible. And, we could spent many more decades characterizing some aspects of Yucca Mountain and still have uncertainty distributions. When it comes to addressing uncertainty which is a slightly different topic, but very much intimately related with conservatism, we have different approaches and there's basically two end-members in the whole continuum between those two. We can use deterministic bounding estimates which we do in some specific instances and we can use the probabilistic statistical modeling techniques that incorporate representations of uncertainty. And, we have used the hybrid approach. Basically, in the TSPA, you will see both being used.

Next, regulatory requirements. And, this is a mixture of regulatory requirements in 10 CFR 63 and statements by the regulator in the NUREG, but this is an important thing to keep in mind. That proof that the repository will conform with the objectives for post-closure performance is not to be had in the ordinary sense of the word because of the uncertainties inherent in the understanding of the evolution of the geological setting, biosphere, and engineered barrier system. And, I, too, am sorry that we didn't hear this talk--I was scheduled for yesterday morning--which addressed one aspect of this.

Conservatism is an accepted approach for addressing uncertainty. If you look just at the highlighted text, conservative estimates for the dose to the reasonably maximally exposed individual may be used to demonstrate that the repository meets regulation and provides adequate protection. So, we feel empowered by these words to use the approach that we're using.

Next? When conservatism is used to simplify the analysis or decrease the need to collect additional information, we know care must be taken to evaluate the effects of this conservatism. The language in 63 is that the performance analysis should focus upon the full range of defensible and reasonable parameter distributions rather than only upon extreme physical situations and parameter values. The total system performance assessment is a complex analysis with many parameters and the Department may use conservative assumptions--again this comes from the NUREG--to simplify its approaches and data collection needs. However--and I think we do take this "however" very seriously--a technical basis that supports the selection of models and parameter ranges must be provided. And, you saw an example yesterday of where we said that we made a decision on a feature event or process. We showed you that we had a technical basis for that decision and you illustrated basically the thing that we go through with the NRC all the time which is, you know, the words that we all fear is I am not convinced, you know, because we do need to make a compelling case in all of these instances.

Next? NRC indicates that the technical bases for a safety analysis report--and this is now looking into the future. You've submitted your safety analysis report, you're looking into the future, you will learn new things over time, and the safety analysis report may be considered to be unchanged in future analyses if they can be shown to have been conservative or essentially the same. So, the highlighted, "Changing any of the elements of the method described in the SAR as updated unless the results of the analysis are conservative or essentially the same," this is in 10 CFR 63.44.

The integrated issue resolution status report, this is the KTI process that I referred to earlier, the Key Technical Issue Resolution Process. Generally, important uncertainties are addressed in total system performance assessment through a variety of approaches such as parameter ranges and conservative modeling. And then, it goes on to say the risk insights provide a basis for focusing on the more important technical issues. Basically, they're saying that we should address things through a risk informed approach.

Next? The EPA technical support document of August 2005, this is a document put out on the internet in support of the changes to the regulation that Betsy Forinash reviewed for us yesterday. Some of the language in there that was prepared by a contractor was based on a review of DOE, EPRI, and NRC performance assessments. And, it says, in the 10,000 year engineered system time frame, under principles of reasonable expectation, there is a framework of assumption, conservatisms, and data that enable the defensible characterization of performance and uncertainty using the probabilistic TSPA methods. I think that's all I need from that one.

Next? We also participate in the international programs mainly of the Nuclear Energy Agency on performance assessments and several documents have been published by the NEA just this year and the previous year that basically reflect the international status of performance assessment work. In one of the meetings, it was noted by participants in that meeting, meaning people from different international programs coming together to discuss issues, a mixture of conservative and realistic assumptions in a safety case is inevitable and this is recognized by regulators. In those parts of the performance assessment where both types of assumptions are present, the assessment must err on the side of conservatism, but reviewers should be aware that this obscures areas of uncertainty and this is exactly what Dr. Hornberger said in his opening remarks.

Another document published last year, I'll just read the last line. "Conservatism is inevitable and greatly to be preferred to optimism, but should be used and managed judiciously." And, the opening statement on the first slide was that we will try to avoid optimism.

Conservatism has been and continues to be a part of the licensing approach adopted by DOE. It allows us to simplify models, reduce the need for additional data, and it's a way to address alternative conceptual models and make decisions regarding them. Conservative representations are designed to be cautious, but reasonable. And, I think this is an overarching theme in the way that we approach things. We want to be cautious, but reasonable. This approach balances the need to be defensible with the desire to incorporate the full range of possible parameter distributions based on the information that we have at hand.

Post-closure performance assessment rests on a factual basis that provides a defensible prediction of performance. And, here again, I'm just repeating my theme, we do not want to underestimate potential dose. The performance assessment approach is pragmatic. We do seek to represent the factual basis accurately. We believe uncertainty is being appropriately treated through this cautious approach involving a reasonable degree of conservatism where warranted. Conservatism, we believe, is appropriately being evaluated through risk-based importance evaluations and sensitivity studies are being used to enhance their system understanding.

These are NWTRB observations, observations from your organization. The DOE often deals with uncertain features and processes by making conservative estimates of their effects on radionuclide transport. And, in this particular May letter, the Board identified some areas where you suggested additional work might increase basic understanding, narrow the wide range of predicted radionuclide transport times, and increase confidence in predictions of the performance of the natural barriers, in particular.

Our response that same year and a few months later indicated that we have included the most significant uncertainty in the models. Of course, this is always caveated by "based on the information that we have at hand". In some cases, conservative approximations have been used. Continued evaluation of these processes will be included in the performance confirmation plan. And, key conservatisms are being evaluated as part of the science and technology program. And, I think yesterday Mark gave a very nice overview, and in response to your questions, actually went into this in some greater detail than even his viewgraphs indicated.

Here's a very specific NWTRB observation and our response. When it comes to seismicity, you stated that the

DOE may find conservatism and attractive because it can provide a way to show regulatory compliance in the face of uncertainty. But, as stated above in your letter, DOE and BSC scientists agree that many of their estimates, meaning our estimates, are highly conservative or physically unrealistic. Now, of course, this is something that needed a more profound response than the more generic statement of the previous viewgraph.

Our response of October that year indicated that seismic ground motions at annual accedence probabilities of less than 10^{-6} per year are highly conservative and may be physically unrealizable. So, we agreed with you. And, we launched at that point several different studies to bound the very low probability ground motions in order to provide a more realistic set of ground motions. We presented a revised approach to the Board in May of 2004, and in your letter as a response to that presentation, you said we are very pleased to learn that the DOE has initiated a program aimed at deriving more realistic estimates of seismic hazard at the Yucca Mountain site. And, yesterday, you heard a presentation that basically used this new approach.

Now, we launch into the technical part of this presentation and those of you who are technically oriented will welcome Bob who will introduce himself.

ANDREWS: Thanks, Abe.

Let me back up. I've been doing performance assessments for a number of years starting in the mid-80s as a subcontractor to the Office of Nuclear Waste Isolation when we were looking at embedded salt sites and salt domes around the country. I went for a few years to Switzerland to do performance assessments and interpret and analyze a wide range of hydraulic and tracer tests for the Swiss program, mostly in fractured kinetic rocks, but not all, came back to the states to work on Yucca Mountain Project in performance assessment, and have been doing various aspects of performance assessment since being in the Yucca Mountain Project since '91. For a number of those years, I managed the performance assessment, but the last year-and-a-half the focus has been integrating performance assessment into a license application which is in draft form as John talked about yesterday.

So, with that as an introduction, we picked, using the Board's questions, three representative examples because we think they're fairly insightful and will engage some dialogue with the Board associated with the examples implementing the approach and methodology and philosophy that Abe just alluded to which was driven by regulatory concerns and also international precedence. So, we picked these three, in part, the second and third one, because they do reflect, if you will, the lower natural barrier. They represent radionuclide transport if any radionuclides are released from the engineered barrier system into the natural system below the repository and then ultimately through the 18 kilometer compliance point for the reasonably maximally exposed individual. So, two of them relate to the lower natural barrier and its capability. I think the Board pointed out, Dr. Garrick in his opening remarks of the Board's--I forget how he exactly phrased it--interest or concern associated with the capability of the lower natural barrier uncertainty associated with that capability.

The first one we chose as a way of looking at the engineered barrier system, this is the release of radionuclides from the engineered barrier system following a breach of the waste package, whatever the initiating cause or event of that breach may be, and uncertainties associated with that release from the source term and transport to the natural barrier system which is the unsaturated zone below the repository. This has been a matter of some discussion with this Board. The previous chairman of this Board, Dr. Corradini, had some observations associated with conservatism in the engineered barrier system transport. So, we want to address some of those while we're at it up here.

So, if I could have the next slide? Many of these conceptual figures, in fact, all of the conceptual figures, you have seen before. I briefed the Board last September

2004 on the overall performance assessment approach and methodology and the integration of the models and analyses and their abstraction into an assessment of system performance as required in Part 63. So, these conceptual pictures are just kind of leading pictures for me and for you to reorient ourselves to what part of the post-closure system that I'm going to be addressing.

The first one is with respect to EBS. There's a number of features in the engineered barrier system. Some of them, we talked about yesterday. I'm going to talk about features inside the package and below the package; in particular features such as the cladding, the basket materials, the other in-package materials, the stainless inner barrier of the waste package, the pallet, the invert. But, there are other features of the engineered barrier system in addition to the drip shield and the waste package.

There are a number of processes that occur within the features that I am going to talk about. Those processes are chemical processes, those are hydrologic processes, those are thermal processes, and those are mechanical processes and, in fact, some radiation processes. And, ultimately, the process related to the transport of radionuclides from waste that may be altered in the presence of the expected environments that may occur inside the package once the package has been breached. So, I'm going past where we were yesterday to what happens afterwards, if you will.

While I'm on this, we showed some of the hydrologic processes such as seepage is a hydrologic process, condensation is a hydrologic process, the possibility of imbibition of moisture from the rock into the invert is a hydrologic process, and the movement of moisture, you know, is a hydrologic process. There's a number of thermal processes going on inside the package and exterior to the package if it is hot. You're well-aware and it's been alluded to in the last day-and-a-half about the 11.8 kilowatts per package maximum for the commercial fuel and it's a range of thermal outputs, in fact, from package to package and that causes the temperatures to rise and processes to occur as a result of the rise in temperature both in the package and exterior to the package.

Chemical processes occur and there's a number of-- all of these processes, by the way, are coupled and one of the questions the Board asked associated with this talk is the conservatisms associated with coupled processes. The coupling of those processes have been presented to the Board. The last time I'm aware in detail was May of 2004 where Dr. Bodvarsson and his colleagues talked about the coupling of hydrologic, thermal, and chemical processes in the rock and ultimately in the drift. We did not talk so much about the coupling of those processes in the invert, but that same coupling occurs where we have moisture, water from different sources that interact with invert materials and can modify the chemistry of the invert. Those same chemical processes can happen inside the package to result in changes in chemistry as materials degrade, etcetera.

Let's go on to the next slide. I have broken this discussion of EBS transport, engineered barrier system transport, into thermal hydrologic processes, chemical processes, and then I look at one special case because it was a matter of some discussion, I believe, in Dr. Garrick's opening remarks, as well as some discussion yesterday. Dr. Peters presented some ongoing research associated with secondary phases and neptunium incorporation and potential incorporation in secondary phases. So, I'm going to talk about neptunium solubility of the special case. And, then, the colloids, I think the Board was interested in colloids. One of their questions had something to do with colloids. So, I want to try to hit on colloids both in the EBS and in the natural system.

Okay. So, inside the waste package and the invert, there are a range of coupled processes affecting the thermal hydrologic environment. Heat is created. That does mobilize moisture. It mobilizes it in the rock, it mobilizes it in the drift. You saw yesterday from Dr. Peters some information associated with the cross-drift. That confirmed, if you will, that moisture moves by thermal gradients. I'm not sure exactly how Mark portrayed that, but you might say, not surprising that moisture is moving by thermal gradients. That happens in the drift, that happens in our models, and what happens when it gets into the package is a matter of some uncertainty. Now, how moisture may or may not move into or out of the package is uncertain. We tried to develop very complex models of how moisture moves in and out of different types of packages and different types of heat sources and what happens to that moisture once it gets into the package recognizing that the transport, radionuclide transport, generally requires the presence of moisture in some form for radionuclides to either be diffused through concentration gradients or advected through the movement of water or some combination thereof.

Because of the complexity associated with moisture moving into and out of the package and what happens in the details of moisture inside the package, a number of conservative approximations were made; cautious, but reasonable, as Abe said. One is that, regardless of the type of package or the type of waste form or the heat produced by that package, there was no loss of water, there was no loss of moisture. There was essentially a continuous, assumed thin film on the waste form, on the degrading internals of the waste package materials, and there was no consumption of water due to the degradation of the iron bearing metals that are also inside the package. There's carbon steel in the package as the structural support members or support members and there's stainless, you know, inner package. Those materials will degrade with varying rates and the role of affected chemistries we'll get to in the next slide. But, the conservative approximation that was made in order to remove some of the complexity associated with moisture moving in through a cracked waste package or a breached waste package was to let the moisture be there if the temperature is below the boiling point of water in the package. So, there's no moisture in temperatures above boiling point which Yucca Mountain is 96 degrees C, plus or minus. But, once I get below that point, the conservative assumption is that moisture is there and it has coated, if you will, through a thin film several monolayers thick, enough film thickness to allow alteration of waste form to occur and allow the alteration and degradation of the internals of the package to occur.

The last bullet is sort of key. Those current model assumptions--that's the current technical basis--you know, reduce the amount of information or modeling or complexity that's necessary to evaluate the post-closure performance. It is a concern that the Board has raised some two-plus years ago by the previous chairman, but the complexities associated with detailed analysis of moisture movement in and out of a range of cracks and the consumption or migration of that moisture once it gets into a package that's degrading, you know, thousands of years from now is just deemed to be too complex to incorporate in the analytical basis for the TSPA, total system performance assessment.

Can I have the next slide? Okay. Now, I'll start with chemistry. Here, I've broken the discussion into the chemistry in the invert versus the chemistry inside the package because they are different. The chemistry in the invert which is a coupled chemistry process and is affected by the source of the water and the chemistry of that water which is a function of time, this coupled process of chemistry, evolution that Dr. Steifel, I think, presented to the Board in May of 2004. That coupled evolution of chemistry in the rock does affect the chemistry in the drift. It's a starting point, if you will, for chemistry in the drift, but it also can be modified by condensation effects, imbibition effects, and interactions with the drift materials. So, the chemistry does evolve and it is coupled thermally, coupled hydrologically to the chemistry evolution in the rock. That chemistry is important for several reasons in the drift and in the package because it affects the solubility of radionuclides. It affects the transport characteristics of radionuclides whether they are in colloidal form or whether they are in dissolved form. So, it is an important consideration that has to be factored into total system performance assessment models.

When it gets inside the package, again it becomes somewhat more complicated. Now, you have to evaluate whether you think the degradation characteristics of materials that are in the package, are they under oxic condition or anoxic condition as they are degrading? I don't believe this Board, but maybe other boards have questioned the applicability of the redox state inside the package when the metals are degrading and when the waste form is being altered. To avoid that complexity, the conservative approximation that we've made currently is that it is oxic conditions inside the waste package. Those oxic conditions in this environment are highly likely because it's an open sort of system, air does move in this system. The exchange of air with the rock air is fairly--it's quite a permeable system so it occurs readily. So, letting out the oxic inside the package seems reasonable, but it does have the effect of, you know, increasing waste form alteration rates because they're higher in an oxic condition than they are in a reducing environment, and also enhances the radionuclides solubilities, both of which tend to increase releases from a waste package that may have been degraded in a Yucca Mountain type environment.

Go on to the next slide? Can we have the next slide, John? Searching for the next slide. We have crashed, okay.

Let's go on to the next slide. I think you have it in the handout, if that's okay. We're now talking about neptunium solubility; solubility in general and neptunium solubility, in particular. The plot that I have on the left side of this figure--I'm on Page 18 if you're just following along--I presented to the Board in February of this year associated with the Department of Energy's at that time reevaluation of all the data they had and a range of possible controlling phases that may affect neptunium solubility. There was at that time some evaluation of whether it's an Np2O5 controlling phase, if it was a single controlling phase, whether it's Np2O5 or NpO2. Some previous assessments had been conducted assuming the Np2O5, a representation which that very top, you know, curve that you see on this plot. All the data points--and most of these data points are collected over the last, I think at that time it was nine years. So, at this time, it must be about 10 years at Argonne National Labs and some other data collected at Pacific Northwest National Labs from drip tests on actual spent fuel specimens looking at a range of possible neptunium concentrations, you know, interpreted as solubilities for a range of possible pHs in this case. The decision at the time was to go to the NpO2 representation as a reasonable representative of cautious, but reasonable representative evaluation of neptunium solubility inside the package as a function of uncertainty in the in-package chemistry. So, uncertainty in pH and CO_2 concentration, etcetera, inside the package.

The other approximation though that was made was because of the complexity, although there is some information to support retrograde type solubility for neptunium and a number of other radionuclides, i.e. it's more soluble at-- I'll get this reversed. I always get this reversed. More soluble at higher temperature--sorry, lower temperatures and less soluble at higher temperatures. And, the data are collected over a range of temperatures. These data, I should have put it on this slide. You have the slide from last February. It may not be readily available, but you have it where we indicated what temperature range some of these data points were at. Some of these data points are at 25C, some of these data points are at about 90C. So, there is a range of temperature represented on the data plots. But, the reasonable representation was to simply use the 25 degree C solubility curve shown here, not the temperature dependent solubility curve. Were there to be more information, more data, it may be reasonable to incorporate sometime in the future an alternate temperature dependent solubility. But, at the present time under present understanding, the decision was made to use this cautious representation of non-temperature dependent solubility.

Going on to the next slide--

KADAK: Can I just comment? I don't see where you draw these curves based on the data.

ANDREWS: The curves are based on a model. The model is, you know, a thermodynamic based model representation of, in this case, neptunium with a range of chemical conditions in that model such as pH, PCO_2, PO_2, etcetera. So, it's a thermodynamically based representation of what would be for a considered stable phase--the stable phase being in this case NPO_2--what would be the predicted, you know, outcome of neptunium solubility. It's not a curve fit to data, but it's a comparison of data collected in the lab under a range of different conditions, different temperatures, different environmental conditions to a model conducted over a range of conditions, a thermodynamically based model, as all the other solubilities are based on these thermodynamic models and they're also compared then to the observations to evaluate their representativeness.

I think, Dr. Peters talked about secondary phase. Let's stay on this slide for a little bit longer. I was going to bring it up later, but I'll just do it now. Secondary phase representations, the potential for a secondary phase representations are neptunium being incorporated into secondary phase. It's been postulated in the literature. I gave you in February four literature sources for your review where they summarized their understanding of the potential for neptunium phase incorporation. And, these are recent values collected over the last year or two, 2004-2005 data sources, which indicated that it is potentially a very possible condition that neptunium could be incorporated in secondary phase materials. I think, you saw some information yesterday and the words from your consultant--if I can paraphrase them--were this is discouraging, associated with the possibility of neptunium being incorporated in the secondary phase. A number of people have postulated that that's a very reasonable model, a very reasonable representation, but the data currently available, some of it presented to you yesterday, don't support that incorporation. So, the cautious and reasonable thing is to use an alternative representation which is what we have done.

Colloid transport. Colloids can exist in many different forms inside the package in the natural system, many different sizes. Their stability, their filtration, their formation itself are very much a function of the chemistry. Their function of chemistry in the package, their function of chemistry in the invert, and, in fact, their function of the chemistry in the natural system. Colloids exist. The question is then how are they transported in both the engineered barrier system and in the natural system?

First off, on the stability and existence side because if they're unstable, then that's somewhat irrelevant with respect to a transport because they would be stabilized and whatever radionuclides may be sorbed to these colloidal materials would come back off and be in solution. So, the first thing is to evaluate their stability. That's what we have done. The stability is a function of the pH and ionic strength. There is significant data, not all project data, this is international issues. So, a lot of other countries, in fact, have looked at colloid stability over a wide range of environmental conditions and some of those environmental conditions are relevant to Yucca Mountain. So, we've used that portion of the overall data that are relevant to Yucca Mountain to evaluate the stability of colloids in our system, in our engineered barrier system and in our natural system.

It's generally true that colloids require advective movement, i.e. the physical movement of water, but that's a generality. Colloids can be in a wide range of sizes and some of the smaller sizes, it is possible to postulate, as has been done, that they may be diffusive, i.e. move through a concentration gradient in addition to being advectively moved through moving water. We have considered that possibility in the current performance assessment models that colloids can diffuse through these thin films that were in the first slide that I was talking about and, in fact, can diffuse out of the package and can when they get to the invert either be advected or diffused through the invert. So, that diffusive colloidal transport, which the information is somewhat limited, has been conservatively represented in the performance assessment.

Let's go onto the next slide, I think, which is natural system. Okay. I'm going to switch, going to the natural system starting with the unsaturated zone. This is again a conceptual slide from last September. Let's go onto the next slide. There's two main areas of conservatism. By the way, some of these conservatisms were acknowledged in that Sandy Cohen & Associates document that Abe alluded to, the EPA has attached to their website as part of their rulemaking process, Form 197. They went through essentially feature by feature, process by process their interpretation and their assimilations--it's probably more assimilation than interpretation--of DOE, NRC, and EPRI's performance assessments and many of these assumptions that I'm talking about today were included in EPA's contractor document.

One, propagation of future climate effects through the natural system. As you're aware, we've discussed, I think, a couple of times, you know, assumed climate changes at 600 years and 2,000 years during the 10,000 year currently regulated time period. When those climate changes occur, there's ample evidence at the surface to indicate the climate changes can occur relatively quickly at the surface. So, they propagate to changes in precipitation, changes to temperature reasonably quickly at the surface. What that means with respect to infiltration and unsaturated zone flow at the subsurface is quite uncertain. In order to simplify the analysis, we have assumed that when the climate change occurs, 600 years, 2,000 years, that climate change occurs, first off, instantaneously which is not unreasonable, but it is instantaneously propagated through the entire unsaturated zone and through the saturated zone. So, those two systems immediately and instantaneously go to a new phase state. I presented some information to this Board in February that looked at what might be interpreted as actual time variations in the subsurface. Now, maybe when I get to the unsaturated zone, it is not an instantaneous step function change, but it is some damp variation, i.e. it takes some period of time to propagate through the unsaturated zone because all those data, the USPS data associated with opal (phonetic) coatings and things like that. But, that would be a very complicated model. That would require many other inputs, data which would be somewhat lacking, and the decision was made to be reasonable and cautious and simply assume that the climate change is immediately propagated through the natural system. It's also immediately propagated to a rise in the water table associated with that increased, in this case, precipitation, and therefore, infiltration, and therefore, percolation.

The next slide is probably maybe of more interest to the Board because it directly goes at, I think, two issues that Dr. Garrick made in his opening remarks to us all yesterday morning associated with in this case unsaturated zone transport. Unsaturated zone transport, we have a fractured porous media at Yucca Mountain. It's highly fractured, as you're well-aware. And, distribution of those fractures is variable dependent on the rock type and where you are stratigraphically. Once I get to transport, not flow of water, the flow of water can be reasonably constrained by a lot of observations that Dr. Bodvarsson has presented to this Board on a number of occasions. The chloride concentrations, the temperature distributions, you know, matrix saturations, pneumatic pressures, etcetera, all help to constrain the range of reasonable percolation values, i.e. net flux values through the unsaturated zone. When it comes to transport, i.e. the movement of individual radionuclides whether in dissolved form or colloidal form, the amount of information is a little less. There is some. We tested at Alcove 1, we tested at Alcove 8-Niche 3 two times, actually more than two times, different sequence of tests. We tested at Busted Butte just on the southern tip of Yucca Mountain. To evaluate transport characteristics, we've also done a number of laboratory experiments. We've done matrix properties principally in terms of diffusive characteristics of the matrix and looking at transport properties, in particular absorption characteristics of the rock and minerals typical of Yucca Mountain.

But, the key issue is where do the radionuclides go when I'm in this fractured system? There is two main elements here that we talked a little bit to the Board, I believe, last time about. One is the interface area between the fractures containing radionuclides and the matrix. A small interface area means generally less diffusion into the matrix and quite rapid transport. And then, the effect of matrix diffusion coefficient of the radionuclides during the fractures as they try to diffuse into the matrix. A well-known process, a well-accepted process, but characterizing that process especially considering these two aspects is uncertain. Both of those aspects are uncertain, the degree of small fractures and how they communicate and how they interface with these radionuclides that are moving through the fractured system and this effective diffusion coefficient that goes into the matrix from the fractures. This effect, by the way, is a very significant effect. It's particularly significant for any radionuclide that sorbs because when that radionuclide is diffused into the matrix, if it has a significant sorption and significant maybe Kds in the range of several up to several hundreds for our type of radionuclides and we do have radionuclide-specific sorption factors for the rock types of Yucca Mountain, it can significantly delay the transport of radionuclides to the water table and, in fact, for some radionuclides, can prevent their transport from the repository horizon to the water table. And, as you'll recall, the definition of a barrier is to prevent or substantially reduce. So, we are talking about a barrier capability here of the unsaturated zone below the repository. Whereas, the capability of that barrier is a function of the uncertainty associated with this process of matrix diffusion.

The third bullet here though is key, the direct measurement in-situ. Direct measurement of both of those aspects, you know, the interface area, it's not just, you know, measure all the fractures and determine a geometric interface area; this is interface area where the radionuclides are moving. It's going to be a different interface area than just a geometric interface area. That's not an easily measurable quantity in-situ. And, when you do try to measure that quantity, as we have tried to measure that quantity, both in Alcove 8-Niche 3 and in Alcove 1, over reasonable periods of time, i.e. months or years, not hundreds or thousands of years, I can't do a natural test under ambient conditions because the transport times are too long. So, we forced it. We pond water at the surface or we pond water in Alcove 8 and we then add tracers. So, we're forcing the system. Now, you have to question--or what one does is question, okay, how representative are those conditions to expected conditions?

Flip on to the next slide. We have a couple of--or no--before I go to the next slide of additional information, this is a current representation. Current representation is a conservative representation; cautious, but conservative. It essentially assumes that the major fractures are the ones that are evaluated for this fracture-matrix interface area. Secondary or tertiary or quaternary, smallest drill fractures are not considered in the transport of radionuclides in the unsaturated zone. The effective diffusion coefficient is then one based on laboratory derived diffusion measurements. So, there's a reasonableness in the approximation of matrix diffusion in the unsaturated zone, but it's also conservative as we will show on the next slide.

Let's go on to the next slide. Well, it seems like when there's a data plot, the system doesn't like it. Okay. The next slide is two things on the left side. The upper left hand plot is the actual Alcove 8-Niche 3 data for the fault test. What's shown there are the actual data points and interpretation using a model with the original interface area. Read that to be the geometrically derived interface area and matrix diffusion associated with a core, laboratory derived matrix diffusion. You see that the original interface area and the actual data don't match very well. Dr. Kadak was talking about another example where data didn't match very well with a model. However, by modifying one term, essentially the interface area, essentially allow more fractures, not just the major fractures, but additional fractures to take part in the transport mid-take of two tracers from Alcove 8 down to Niche 3, a distance of about, I'm going to say, 30 meters and somebody will probably correct me if that's off by too much. So, it had to be increased. In this case, it had to be increased by a factor of 45 to get that alternate representation of observed versus simulated.

Another way of looking at other information--this is not unique to Yucca Mountain, by the way. This issue of how many fractures contribute to transport of any constituent from a transport perspective and what kind of diffusion there is between the fractured system and the matrix system is not unique to us. It's a worldwide issue. I've shown here on the bottom left hand plot a figure from a literature article, particularly by Dr. Liu and some of his coworkers at Lawrence

Berkeley National Lab published in 2004. Each one of those little triangles--this is, I believe, a WRR paper, Water Resources Research paper. I'm not sure. We can get the reference for you. It shows kind of a scale dependency of diffusion coefficient where he has test scale along the horizontal axis and what he's called an effective matrix diffusion coefficient which is kind of a scale dependent matrix diffusion coefficient which may have elements of a fracture-matrix interface area buried in it. And, you see this kind of increasing trend as the scale of the observation increases. The scale effect or the effective matrix diffusion coefficient goes up. Our scale of interest at Yucca Mountain is on the scale of 10 to 300 meters, you know, 300 meters from the repository horizon to the water table. These tests started with research done by Dr. Retniex (phonetic) in Sweden in the mid-90s, mid- to late-90s, and other researchers. This represents--oh, there is about 30 data points on there. It actually represents, I think, about 15 or 20 locations. It's not all--it's not 30 different locations. But, you see some increase in trend. Now, what we use is--our scale is essentially at 1. We don't use an enhancement factor for matrix diffusion. We don't include, if you will, the potential of an defective matrix diffusion coefficient that would scale laboratory derived values up to some other values.

We need to go to the next slide. Okay. So, there is some recent information to support potential scale dependency of this process. Uncertainly exists in whether that's a scale dependent process or not or whether the fracture interface areas that we've used are--although we think this is representative of the geometric relationship, they may not be representative of smaller scale fractures were they to be included in the representation. But, verifying that they are there and take part in the transport process may require additional information or additional analysis. In order to do that, you know, the science and technology program has embarked on additional research, additional--I don't think--maybe some testing. Bo would have to clarify that on exactly this process and its scale dependency to evaluate, you know, whether it's reasonable even under stressed conditions, i.e. over-stressed conditions, that the scale dependency or effective matrix diffusion coefficient or fracture-matrix interface area, essentially, how conservative are our current representations. Our current representation is cautious, we believe, but reasonable, but additional information may say something--how cautious we are quantitatively.

Let's go on to the next slide. Okay. This is conceptual picture of saturated zone. Let's go on to the next slide. The future climate effects the propagation of the saturated zone just like they are in the unsaturated zone. I can skip over that. Let's talk a little bit about colloid filtration. The Board, I believe, asked some colloid related questions to us. Although there is no direct evidence of filtration in our saturated zone tests, there are a range of, if you will, retardations or attenuations of colloids in our saturated zone tests. The current basis for the attenuation of colloidally transported radionuclides in the saturated zone is based on our observations that have been made to date, principally at C-wells.

Dr. Peters presented some information yesterday on some additional colloid testing using microspheres which is kind of an analog of colloids. We don't test with the radionuclide-bearing colloids in the saturated zone or anywhere except in the lab. And, those tests that Dr. Peters presented yesterday confirmed that the range of attenuation of colloids currently represented in the model is reasonably representative by the saturated zone testing done in collaboration with Nye County and Los Alamos National Labs. In other words, colloids are retarded in the natural environment. Whether or not they are actually filtered--and filtered would just be equivalent to a retardation of infinity, let's call it--or not is indeterminate, you know, based on the currently available information. So, the reasonable and cautious approach with respect to colloid transport in the natural system is to allow attenuation, allow retardation using the available information that we have from the field and from the lab which covers quite a broad range of retardations, quite honestly, but not to allow permanent filtration in the saturated zone. In the unsaturated zone between layers of different pathologies or fractured porous media into a porous media, there is some filtration depending on size, exclusion characteristics of the media, and the size characteristics of the colloids.

A third area of, I think, some interest to some because it's been postulated by some that there are potential redox conditions in the saturated zone and were the radionuclides that are being transported in the saturated zone to find these redox conditions, they need to do the solubility constraints or do the retardation. There would be significant and very significant retardation and, in fact, precipitation potentially of some dissolved radionuclides were there to be a reducing condition in the saturated zone.

We have currently represented the saturated zone as oxidizing along the likely flow paths from the base of the repository to 18 kilometer point of compliance. And, let me show you some recent information. Oh, we do have it this time. For those of you who have black and white--I think, the Board has color, doesn't it? Okay. For those of you who have black and white, I apologize because this really was meant to be in color. Shown on this figure are individual boreholes where we've in some cases evaluated the redox conditions, in other cases, the redox conditions or the redox data in the saturated zone groundwaters are indeterminate or haven't yet been evaluated. And, superimposed on that is one representation of potential flow fields from the repository down to the compliance point and, in fact, beyond. The compliance point is--well, I probably should find it exactly on there. It's about a third of the way up that plot.

What you see here in the blue are what have been determined based on these characteristics to be generally oxidizing environments. Virtually all, but not all of the Nye County boreholes along the likely flow paths or in the immediate vicinity of the flow paths are considered to be oxidizing conditions. As you get closer to the repository, there are some wells in the fractured media that appear to have reducing conditions, i.e. they're red. If the groundwater did, in fact, with some high degree of confidence encounter those reducing conditions--and, here, reducing generally corresponds to about greater than 200 millivolts--then the effect--we'll illustrate on the next slide--could potentially occur. When this is just retardation sorption coefficients of technetium, technetium is a dominant dose contributing to radionuclides in the Yucca Mountain system, in part, because it is non-retarded under oxidizing conditions or only very slightly retarded, in part, because of its high solubility, it can diffuse reasonably rapidly out of the engineered barrier system if it's a diffusive transport mechanism from the engineered barrier system. So, this is an important radionuclide. And, here, you see a 10^4 increase, 10,000, a factor of 10,000 increase in sorption coefficient, if we could confirm that we had reducing conditions along the likely flow paths in the saturated zone.

However, going back to the previous slide, you see there's some uncertainty about where these flow paths go. There's some uncertainty about whether those flow paths are likely to intersect these potential reducing conditions or not. So, the prudent, cautious thing that the Department has done, so far, is to simply assume that we have oxidizing conditions and there is, if you will, no barrier credit taken for the potential reducing conditions that may exist in the saturated zone.

I think that's it for the examples, isn't it, John? And, now, Abe has--oh, sorry. I have one more slide. I think maybe I hit these--oh, wait, let me go back to that one. This is an important point, third bullet on that slide. Even if the Department from a lot of additional information, additional testing, additional analyses were able to confirm that the likely saturated zone flow path--and I just told you how that uncertainty would need to be addressed--do encounter reducing conditions, the obvious question that anyone would ask--and, in fact, the regulator did ask in the KTI agreement some four years ago which the Department responded to--is what would happen in other future condensates? How do you know that those reducing conditions would stay there and what would happen if it changed from a reducing condition to an oxidizing condition, i.e. you potentially flushed it off of a reducing--you know, a sorbed or precipitated system. So, it adds not only a complexity to the model, but it adds a regulatory complexity in this case to address that additional effect given that we're interested in not just the present day conditions, but the longer term climatic conditions and flow rates. So, again, as with all of these, reasonable caution or cautious reasonableness has been used in the representation of saturated zone transport.

Now, with that, let me turn it back over to Abe for some summary comments and then I know we'll be happy to address your questions.

VAN LUIK: Okay. Going on to the summary and this is reiterating a few things that I said at the beginning, but the primary purpose of performance assessment is to demonstrate post-closure regulatory compliance. And, as I said in my opening remarks, this includes demonstrating to the regulator and anyone else that we do have an understanding of the system. We illustrate and evaluate the system to subsystem and process level sensitivity studies. We will provide a demonstration of post-closure performance that does not underestimate dose. That is our goal. That is our policy. Accordingly, our assessments are consistent with a cautious, but reasonable approach articulated by the National Academy of Sciences, the Environmental Protection Agency, and the Nuclear Regulatory Commission. Relevant observations related to processes should be reasonably explained by the models, however. The effects of conservatism are being evaluated at the process, subsystem, and total system levels using sensitivity analyses.

Can I have the next slide? Some external comments have indicated a desire to parallel the conservative compliance assessments with realistic non-conservative assessments to allow evaluating the safety margin. This is a very effective concept. We have looked at aspects of safety margins, just aspects, with a range of sensitivity analyses at the process and subsystem levels. We have considered approaches for developing less conservative assessments in certain areas. Identifying less conservative representations, however, may require additional data or modeling complexity. And, of course, importance analyses, we want to be risk informed, are to be used to guide the need for such efforts.

But, it should be kept in mind as we are talking about realism, the NRC wrote in its statements of consideration accompanying 10 CFR 63, I think a very important point. The performance assessment evaluates potential doses, not actual doses. For example, the specification of the reasonably maximally exposed individual is considered appropriately conservative for evaluating performance, but, most likely, is not an accurate prediction of what will happen during the next 10,000 years. So, the very basis of our one aspect of our modeling, the biosphere, for example, has been defined in such a way as to provide a reasonable, but cautious approach to that aspect of the modeling. I think these are important things to keep in mind when we talk glibly about realism.

Next? The role of conservatism in conducting performance assessments is acknowledged by the regulator. I've already mentioned several quotations. And, we believe that we continue to use appropriate conservatisms to reasonably enhance the confidence in the technical basis for the post-closure performance assessment. That is our belief. Given the complexity of these assessments, there is a need to carefully evaluate the conservatisms to ensure no unintended optimisms. One of the questions was where have you been optimistic? We have in no place intentionally been optimistic. And, we are cautioned by the regulator and we do take this seriously to look at potential risk violation. The fear is that by being overly conservative and going to very large uncertainty distributions that you are purposely sampling an area that are very unlikely to reduce your risk. So, we continue to evaluate the range of conservatisms that we are about to insure that there's no unintended risk dilution.

Next? Based on recent analyses and data, some of DOE's models have been modified to remove selected conservatisms. And, we do appreciate the insights that the Board has offered on this issue. In fact, last year, we addressed six conservatisms and we found that there was a sufficient basis to reduce four of those conservatisms. The other two, we found the basis just wasn't there. The goal is analyses that rely on the data that we have so that they can be defended and allow us to have confidence in the performance assessment at this point in time. Will we learn more in the future? We are a learning organization. We intend to have a continuous improvement program in every aspect of this organization including the scientific and the performance assessment aspects. And, as part of that, the DOE's science and technology program, just part of that--we also have a mainline program that continues to evaluate and continues to seek improvement. But, the science and technology program continues to develop data to evaluate and potentially reduce conservatisms in post-closure models. As these things are completed, the program will evaluate the conclusions and it may be included in future revisions of models. It is expected--and this is addressed as another one of the questions--that selected reductions in performance assessment and conservatism may be made in future years. That is our expectation. And, we have planning of ongoing performance assessment related work for fiscal year '06 in progress given the multiple constraints that the program is facing at this point.

I believe there is one more. No, that's it. So that, in a nutshell, is what we are about. And, I believe that one of the things that I meant to say earlier is that I personally find it very useful to be reading--I have a very privileged position, actually, because of my interface with the international programs. I have read seven recent--meaning within the last decade--performance assessments published by other programs and I've also read, of course, NRC's work and the EPRI work and I find as a personal thing, I find it very satisfying that basically the more material the international programs become, the more they begin to look like us in terms of having to back away from strong statements and becoming more and more cautious.

The EPRI performance assessment, I personally use as kind of a benchmark if we were to do everything and make the most reasonable estimates that we could of things. This is probably about where we would come out, but I think the EPRI performance assessment people would readily admit that they are not preparing those performance assessments for defense in any kind of a public forum, that they are preparing them to gain insight. And, I think we always have to be cautious when evaluating insight calculations versus the mainline program calculations that are to be used to show regulatory compliance.

HORNBERGER: Thank you, Abe and Bob.

VAN LUIK: Thank you.

HORNBERGER: That was just about perfect timing. Thanks for keeping on time.

Ali is going to run the discussion.

MOSLEH: Thank you very much. I've been given the easy task of keeping the rest of this session on time.

So, the floor is open for questions.

ARNOLD: Arnold, Board. I have an uneasy feeling that this thing is backwards. I'm used to an engineering process in which you design something to do something and then you figure out, well, I've got to get a license for this thing. So, I then do analyses using a different set of ground rules incorporating conservatisms and so forth as required to get the license. What I hear is that you guys start from the need to get a license and work from there. And, it leaves me unsatisfied.

VAN LUIK: I don't know if this a statement or a question, but I think it's a valid point that you're bringing up. We are preparing an estimate of performance with a system that has not yet been built. We are seeking permission to start building this system as we learn things, and as we have an as-built system, we will be obliged to reevaluate that system as time goes on. But, we need to be able to give the regulator a basis for coming up with a finding that there's a reasonable expectation that the system that we are proposing will protect global health and safety.

ARNOLD: But, I still think you've left out the necessary first step which is design a system to do something.

VAN LUIK: Yeah. Well, perhaps we are designing a system to do nothing basically except contain.

MOSLEH: John?

GARRICK: One of the great appeals to me of a probabilistic approach is it gives you the opportunity to make the transition from basically an assumption based model to an evidence based model. And, as I look at the delineation of conservatisms that you have identified and that we're quite familiar with, I guess, I sort of get the feeling that there's a bit of an inconsistent application of probabilistic principles. I know of no better way to address conservatisms than probabilistically. Do you have evidence of a reducing environment, for example, in some locations? That evidence somehow ought to manifest itself in your modeling. And, one way for it to manifest itself is that you associate with that evidence a probability. It seems to me that if you did that and each time you encountered an assumption that is considered to be a conservative assumption, you would probably end up with quite a different result than you have, number one. And, number two, you would be consistent in the invoking, if you wish, of a probability thought process in a probabilistic performance assessment.

I see a lot of inconsistency in that regard. I see some assumptions that clearly are addressable in terms of some supporting evidence, such as the impact on corrosion products of the stainless steel part of the waste package and yet I see no accountability given to the impact of those corrosion products. I see the temperature regimes being such that there's a lot time at which the temperature is below something like 45 degrees for the Alloy-22. I see no indication in the model where that has been probabilistically accounted for.

So, that's something that really concerns me is that there are some advantages in probabilistic approach and in my opinion the first and foremost advantage is that it allows you to let the supporting evidence speak. And, that way of thinking has not been consistently implemented in the

TSPA, at least as I see it.

ANDREWS: Let me take that, if I can, Abe.

You have quite a few comments and observations in there, Dr. Garrick. So, let's talk about some and I'm going to have to go in reverse as my mind just works better in reverse sometimes. Some of the aspects that you alluded to with respect to degradation characteristics of the stainless and other packaged materials, it included there is a model of degradation characteristics of the steams and of the other carbon steel based and other in-package materials. Those degradation characteristics do affect the transport through engineered barrier system. I did not list it on my list of conservatisms because it wasn't until you just asked it, a question that had been posed, you know, in the earlier communication. I believe it's a reasonable representation of corrosion product degradation. I believe it's a reasonable transport representation and it is reasonably applied specific, the amount of sorption or retention in the package on corrosion products. And, I'm talking about what we've termed stationary corrosion products as opposed to mobile corrosion products such as colloidal corrosion products. There's a reasonable representation of engineered barrier system transport. It's not conservative; it's reasonable augmentation as all of our conservatisms are.

The second example they cited was the long-term and

I think that was even one of your--I apologize, I should have hit that, but it was more appropriate yesterday than today. It's the long-term temperature dependent type corrosion rates that one might expect on a passive metal. We do have data of temperature dependent corrosion wastes for Alloy-22. There is uncertainty in the extrapolation of those temperature dependent corrosion rates to either high temperatures or to low temperatures. Most of the data are in the range, as you just said, in the range from 45 to 90 degrees C and the amount of data that goes to higher temperatures is a little more limited, but we have some and you saw some of it--well, I guess, you didn't see corrosion rates yesterday, you saw initiation of localized corrosion information yesterday. But, there is additional information on corrosion rates at higher temperatures. We now have information at lower temperatures, i.e. lower than 45 degrees C range, that is quite uncertain.

So, the ability to extrapolate or interpolate--in this case, we'd be extrapolating from 45 down to lower temperatures--is uncertain and that uncertainty would have to be reasonably incorporated in the assessments. That uncertainty is included in the 10,000 year assessment. It's probably a little more relevant, however, for longer term assessments. And, you have the draft EPA rule and the draft EPA rule acknowledged that one might, i.e. DOE, might include corrosion rates that are a function of environmental conditions in the repository like those that are expected, environmental conditions in the repository, such as temperature. I'm not sure if the rule says such as temperature or not. And, that would be reasonable. But, you'd have to reasonably incorporate the uncertainty in that temperature dependency.

Going back to some of your opening comments--in a second here I'm going to read back to you some of your opening comments to us just so we're all on the same page here. One approach to evaluate uncertainty is to--especially when it comes to uncertainty in models and the representativeness of models, in particular, the conceptual models of processes is to, as you're well-aware, kind of weight those alternatives, to have some basis for reasonably weighing an alternative representation.

And, let's just take the example that you cited here of potential for reducing conditions in the saturated zone. It would be possible. We could convene, you know, five or six or 10 experts in radionuclide transport in saturated media, such as at Yucca Mountain, and elicit, you know, a range of--based on the data, based on the data, elicit a range of possible conditions that might go from--and this is further reducing along the entire flow path to--I see no evidence for reducing conditions or you haven't convinced me, the expert, one of the 10 experts, that the radionuclides would find those reducing conditions. So, we compiled a very wide range, you know, of possible alternate conceptual models from these 10 experts, all based on the same current observations. And, we could get a range of results which would be enlightening in some ways. It would be interesting to see what that range of results is. But, as Abe pointed out, the Department is, you know, some time in the near future and the future is somewhat in question, but going to submit a license application. The defensibility of that license application and the defensibility of those alternate representations has to be in that license application. And, right now, based on currently available information, the process of approximation is, in fact, to assume that it is reducing within that broad range of possible conditions.

And, by the way, your staff was kind enough to give us the actual transcript--I don't know if it's a transcript or what--of your opening remarks and one thing you said was that--and I think this was a Board position. As I recall, it was portrayed as a Board position. Scientists and engineers should be asked to give their best assessment of performance critical parameters. Responding convincingly, i.e. defensibly, to that request may require increased understanding of the repository system. It may require increased data. It may require increased testing, you know, of the repository system. And then, you go on to say, although some assumptions may be required, they, too, could need to be well-justified.

And, that's where we are. We have alternate conceptual representations. They are reasonable alternate conceptual representations or they wouldn't be alternate conceptual representations. Often, conceptual representations in the NUREG and I think everybody's definition would say it has to be reasonable to be an alternate; otherwise, it's not an alternate. It has to be justified. And, at our present state, these alternate representations that are reasonable--I'm not saying they're not reasonable. You know, the matrix diffusion issue that we talked about or reducing conditions in the saturated zone are, in fact, reasonable, but there's not enough information available today. Where's the sensibility to include them in a license application basis? Now, that's when you really--

GARRICK: Yeah, I fully realize that this business of conservatism is not unlike the discussion we got into yesterday about the drip shield and the waste package, but we need several days to pursue it and we're not going to accomplish that today. So, we're just setting the stage for some future interaction.

MOSLEH: Okay. Thure?

CERLING: Cerling, Board. If we can go to Slide 28? It just seemed to me that, you know, knowing if the water is oxidizing or reducing is such a fundamentally important description of water, that that's really a very key process, and if I, you know, look at that diagram at the flow paths, it seems like water goes from oxidizing to reducing to oxidizing conditions. I can understand going from oxidizing to reducing, but going from reducing back to oxidizing is something that's hard to do once you've lowered that groundwater table and that's such a fundamental understanding of the water chemistry and system that, I think, that sort of very much needs to be explained.

ANDREWS: Well, just let me try this. That's an excellent question which again confirms why it's good to be cautious while being reasonable, I mean. First off, I think part of your question was wouldn't it be fundamental to evaluate redox conditions in the saturated zone and shouldn't you be doing it every time you drill a well out there, DOE. Well, as you know, the rule changed, you know, in 2001. So, some of these borehole locations, in fact, many of the DOE drilled borehole locations, were drilled prior to the rule change, prior to the 18 kilometer compliance point, prior to the need to evaluate the saturated zone transport explicitly in the requirements base. So, there's a reason why some of these don't have the observations that one would hope, you know, might have been made.

But, leaving that aside for the time being, the source of groundwaters--well, first off, the location of the sampled interval, you know, can play a role. This is a somewhat gross representation or an average representation not considering the third dimension. The location of the actual inflowing interval, if you will, the most permeable intervals driving water that's sampled varies all over the map here. Some of them are a little bit deeper, some of them are a little bit shallower. They're not all right at the water table surface. That's one factor.

The second factor is it's been well-recognized and there's uncertainty associated with the magnitude, but there's been well-recognized and, in fact, I think, by a previous Board member who continued to push DOE to evaluate recharged waters along Fortymile Wash and what those vertical recharged waters along Fortymile Wash and what they may indicate with respect to groundwater flow in the saturated zone. In fact, there's very good evidence in some of the Carbon-14 measurements in the Nye County boreholes that, in fact, there is vertical recharge very close and inside of that gradient to those sample points. So, it is not simply a 2-D system, as indicated here, but there are large 3-dimensional effects that would have to be considered were one to try to invoke, if you will, reducing conditions as a retardation mechanism in the saturated zone.

CERLING: Let's carry on with that just a little bit. One of the things about these conservatisms is--I mean, for instance, assuming only oxidizing conditions, but if your reducing zone exists and part of it seems to almost be under Yucca Mountain, then if you have this groundwater table rise, you could put the lower part of the unsaturated zone alternately in oxidizing and reducing conditions and you'd think that coupling that to the colloid problem, that would be good for you to generate colloids. So, I'm not so sure it would actually be a conservatism to assume only oxidizing conditions.

ANDREWS: So, where is the--

CERLING: Well, your red-blue boundary is actually under Yucca Mountain so that would imply that part of it is--there's a potential for reducing conditions--

ANDREWS: Could exist.

CERLING: Could exist and if you have an instantaneous water table rise in your model during climate change, then you could bring reducing--possibly bring reducing waters up, but then later you're going to drop down and so there's a--it would seem to me that's the potential for creating colloids by changing the redox conditions.

ANDREWS: Oh, that was exactly part of the basis for the KTI agreement the NRC raised. They were more talking about transient changes in the saturated zone, but you could envision transient changes in the unsaturated zone. Now, of course, within a 10,000 year time period, we only get to wetter conditions. Within that period of time, our climate assessments are we don't go back based on currently available information, we don't go back to a peasant day type representation. So, we wouldn't drop the water table.

VAN LUIK: I believe, it's also important to reiterate the fact that some of these samples are taken at pretty deep levels within the wells and it would be a very self-serving assumption to assume that the water coming through Yucca Mountain and riding on top of the water table would mix completely to that depth. So, that's another reason to stay the course on our conservative approach.

However, on several of the issues brought up by you and Dr. Garrick, we do look to the science and technology program in the long-term to provide us additional information, especially the thing that you mentioned about the role of the corrosion products within the waste package. They are looking at that quite seriously.

LATANISION: Latanision, Board. Bob, I'm just trying to follow up on some of the questions that Thure has asked. And, if we could go to Slide 17? First, a point of information. What is the nature of the chemistry of the colloidal material we're talking about? Is it corrosion product or what do we think it is?

ANDREWS: I'd have to turn to Ernie or somebody inside the package to give me a little more detail. Some of it is corrosion product, some of it is fuels itself can be colloidal in nature. There are silica colloids, but I'm not sure if those are limited to the natural system or not, Ernie. Dr. Hardin, would you--

HARDIN: Yes, Ernest Hardin, BSC. The colloids are smectite based representing products of degradation of the high-level waste glass. So--

LATANISION: The glass?

HARDIN: Yes.

LATANISION: Yes, okay.

HARDIN: And, they are also iron oxyhydroxide.

LATANISION: Okay. This is known by--how do you get the--

HARDIN: We do know, you know, from observation that the glass degrades that way. And, we know also that the waste package contains a great mass of corroded carbon steel.

LATANISION: Yeah, okay.

HARDIN: And, there's an assumption built in there that the smectite based glass degradation colloids are representative of the, what we would think of as, irreversible waste form type colloids.

LATANISION: Okay. Well, I can--let's accept that. My question has to do with the description--and I think this is something that Thure was questioning--the conservatism of characterizing environment as oxidizing. Whether we say oxidizing or reducing, that's sort of a generic description. And, for example, in an oxidizing medium, you could, for example, produce soluble iron reaction products or you could produce insoluble passive films. Or if it's really sufficiently oxidizing you could actually generate oxygen or release chlorine. So, you know, I think the question that becomes really important is just how oxidizing--and I don't know how to answer that. I don't know how you would do that, frankly, in a package. But, I think the issue describing it as being conservative is not quite accurate for kind of the same reason that Thure was questioning. We don't really know whether you're producing a soluble or an insoluble or, in fact, even an anodic gas.

ANDREWS: Well, let me try to address that and maybe somebody who is better in in-package chemistry than I can do that. I told you I was a transport guy, not a chemistry guy. All right. Let me try a little bit. First off, the range of degradation mechanisms occurring in that package with that water film, you know, sitting on the degradation products--you know, the steel, the carbon materials, the waste forms themselves--there have been a range of predictions, if you will, of in-package chemistry evolution considering uncertainty in some of the aspects that you're talking about associated with degradation rates of those metals in that range of possible environments. That results in uncertainty in things like pH and uncertainty in PO_2, you know, as an output, if you will, and PCO_2 and those uncertainties then propagate into degradation of wastes, solubility of radionuclides, and transport characteristics in that degrading waste package environment inside the package. So, we have not tried to precisely predict, aha, that's the pH and we know it. We're saying that there's an uncertainty around pH, around PCO_2, around the other chemical constituents, around the ionic strength that affect mobility and transport of radionuclides reasonably.

LATANISION: Right. Latanision, Board. No, I understand that. I think what's intriguing to me is the possibility that if you were to say that the colloids or iron oxides and if you were to take the position that radionuclides are absorbed onto these colloids, there are a number of possible things you could do to engineer this system so that that colloidal material would not be released. For example, you could introduce into the system surfactants which might cause agglomeration of the colloids so that it would limit their transport characteristics. Or if you do know that there are iron oxide related colloids, you could literally introduce magnetic filtration or devices that would attract the colloids rather than allow them to be released

. So, I'm intrigued by the possibility that if we knew with some confidence the chemistry, there may be ways of tailoring the internals of the package so that even if there is an intrusion, if corrosion occurs as a great uncertainty and you have a moisture or water intrusion into the package, it's conceivable that you could tailor the system so that even if that were true, you could really minimize or inhibit the release of any radionuclides by virtue of what we've been talking about.

ANDREWS: Okay. And, the engineering enhancements are possible and DOE has a project within the S&T program. I'm not sure if that's one of the examples, but I know they're looking at things like getters and other engineered aspects that could be considered.

LATANISION: Well, that would be very intriguing. Thank you, yeah.

MOSLEH: Andy?

KADAK: Kadak, Board. I'm going to use perhaps an overused phrase. I'll try to be cautious, but reasonable. And, I'm also going to try not to be glib. But, I think there's a failure to communicate relative to what the Board is asking for. It is not that we want you to eliminate conservatism, but to be able to quantify the degree of conservatism that you have in your model. In the nuclear power world, we do Appendix K, safety analysis, for a large break locus. We also have the capability of doing best estimate calculations which for the licensing case, the NRC sees compliance to the regulatory requirements, and we also have a level of comfort that says, wow, you don't even come close to 2200 degrees Fahrenheit and you're about 1800 or 1600 and we feel really good about that. All the Board is saying--and we're not saying that you have to invent new science. You have a lot of scientists and engineers on this project who by essentially their requirement to defend until death their assumption or their model or their parameter range have gone to perhaps extremes in terms of "conservatism". What we're saying is given that you have certain models, given that you have certain understandable phenomena that you have not included, let these scientists and engineers make their best technical judgment that if you were to put them in the model and you could run it, you would see the kind of margin you have. That's all the Board is saying.

I hope I haven't misstated the Board's position, but this is what we're talking about. And, I believe that we have asked the scientists and engineers to give us their best understanding at the present time recognizing that it has to be defensible. We again are failing to communicate. All right. My understanding of your presentation was that you are not going to be doing what we would call a realistic model, is that correct?

VAN LUIK: We are continuing to evaluate how we would do that. We continually run into this problem which you characterize somewhat correctly that at every instance where a judgment has to be made and the scientific basis that goes up, the question is is this reasonable, does this fit the data as we know it, and is this defensible? So, there is a stair-stepping approach. We actually have done simpler evaluations. I think Bob showed one to the Board that was highly praised during the viability assessment days when you took basically mean values and showed a flow-through from one end of the system to the other of that mean value. Do you recall that Bob? And, I think that was praised because it gave insight into, okay, so this is how this works. However, that was not a totally defensible product. It was an insight-giving product. I think what you're alluding to is you would gain a lot of insight by having the total system performance assessment run through once with that same approach, a mean value approximation. But, the trouble is that the mean value has both basis that goes back step-by-step-by-step into the data and at each step a judgment has been made. Does this reflect reasonably, but cautiously--a very much overused set of words right here--what we know and can it be defended?

The glib remark that I made which you seemed to take offense to was meant at those who say you need to do a realistic prediction of the future. This is, I think, where we part company with what's actually pragmatically possible. It wasn't meant--I fully understand where you're coming from and the parallel of calculation. I personally like the EPRI calculation even though we will not use it in any way, but it gives me some confidence and it also gives us some indications of where we can probably get more performance out of the natural system looking at their assumptions and looking at our basis. And, I think, the S&T program makes a promise in the further future to bring us closer to some of those things.

But, as far as doing this, okay, what's your real expected case? Here is what the TSPA does. That's a very difficult proposition.

ANDREWS: Let me add because I'm--

MOSLEH: Bob, if you could make your comment short because we're running out of time.

ANDREWS: I'll try.

MOSLEH: Okay.

ANDREWS: But, we do, Dr. Kadak, do sensitivity analysis, you know, of the sort that you're, I think, proposing at, more or less, the process or abstraction level. If I take an example of the unsaturated zone transport at the process abstraction level, given these alternate conceptualizations of the type that I mentioned here, you know, scale dependency and effective matrix diffusion, there are in the documents sensitivity analyses showing the possible effect of these alternate representations. So, add that, if you will, to subsystem level--in this case, we're talking about the unsaturated zone and the capability of the unsaturated zone to retard or reduce radionuclide movement which is a capability of a barrier on Part 63--we are evaluating it. And, we do that for other parts of the system, you know. So, it may not be rolled up into a compliance demonstration or evaluating the effect on TSPA--some things are. In some cases, the alternate conceptual model is propagated into TSPA and, if you will, sensitivity analyses from a dose perspective are also performed which are enlightening and they're included in the TSPA documentation.

KADAK: What is your best guess as to the degree of conservatism in the current model if you add up all these things? What do you think? Is it a factor of 10, a factor of 100, 1000? What do you think it is?

ANDREWS: Oh, I hate to speculate because I'm not sure all of them have been factored in.

MURPHY: I have one short comment. Could I look at Slide 18, please? And, this may be apparent to you, but solubilities are not concentrations in general. They are in your performance assessments and upper limits on possible concentrations and the Argonne experiment plotted on this figure were not designed as solubility studies and probably are not solubility measurements, at all. So, to the extent that the calculated solubility curves are an upper bound to those is an appropriate comparison to make.

ANDREWS: Yeah, we believed it was appropriate also and reasonable.

MOSLEH: With that, I would like to conclude this session. We had two questions from the floor, but we've just run out of time. I thank you very much for this presentation, and the exchanges, I think, had significant room for continuing the discussion regarding the conservatism, I think. I have a number of questions that I didn't get the chance to ask and I look forward to the opportunity to do so.

I guess, I can turn over the meeting to Dr. Garrick.

GARRICK: Okay. We'll, quite likely, take them up when we get to the public comment period.

I'd like now to ask Steve Frishman to come and introduce our next topic and our next speaker.

FRISHMAN: I'm Steve Frishman with the State of Nevada.

For quite some time, we've been interested in tunnel stability issues and that led us next to wondering why we're interested in tunnel stability issues. When we started looking at a basis for looking into tunnel stability, it sort of led us to a couple different areas, and once we got into those areas, we started thinking, well, it's really more than tunnel stability. It's the operational aspects of a couple areas and those are areas that have had some discussion, at least one as late as yesterday, but still have never been aired at the level that we think they have importance and that has to do with the whole concept of drip shields operationally and the concept of retrieval operationally. These are both of real importance. We think about them in terms of license application where retrievability is not only a requirement of the Nuclear Regulatory Commission, but also a statutory requirement and the use of drip shields has become integral to the performance.

So, we decided that it was time to actually take a look at what DOE, at least, has made available in documentation about the operational approaches to drip shield and also where retrievability is implementable. There have been a lot of questions about it in the past. We've heard the--I'll use the word again--the glib statement that it's just the opposite of emplacement. Well, it isn't. There's much more to it.

So, what we did was we asked Frank Kendorski who has, oh, about 30 years experience in a broad range of underground operations and evaluations in a lot of different specialized areas. We asked him to take a look at what's available from DOE on the drip shield concept and on the retrievability concept and he's looked into it, has what we think is kind of an interesting and revealing report on the state of those issues at this point. So, I guess we have about 20 minutes and Frank will go through some of the things that he has discovered and applied his own experience to out of the available documentation from DOE on those two subjects.

ABKOWITZ: Do we have the report, as well?

FRISHMAN: No, we don't, but we will when we've got a final copy of the report.

KENDORSKI: Thanks, Steve. I'm trying to get a cold. I hope I can be heard.

What I'm going to talk about this morning is a review of titanium drip shield concept and critique of that, retrieval concept and critique, review of features common to drip shield and retrieval concepts, identification of issues that arise from this.

The titanium drip shield, this is already out-of-date from what I saw from Charlie yesterday. The pin arrangement on the leading front end there has now changed to an overlapping ridge arrangement. I'm not sure what the correct term for it is, but a lot of the issues are much the same.

Drip shield requirements are to provide an additional corrosion-resistant engineered barrier over all waste packages and also to provide a physical barrier to protect the waste packages from rockfalls. The overlapping and interlocking are to be a continuous shield for the length of the waste packages in the drift. Each drip shield is made from Titanium Grade 7 and Titanium Grade 24. Each drip shield weighs approximately four metric tons. I made a lot of pains in this presentation to make everything metric. Everything else is in English units. 12,500 drip shields will be needed from the most current information I can find. The total weight of titanium or titanium alloy--and the alloy is 90 percent titanium--is 38,000 to 50,000 metric tons.

This is the from the United States Geological Survey website. The United States Geological Survey is tasked by the Department of Interior and the government to track metal statistics and mineral commodity statistics worldwide and in the U.S. This is titanium statistics for the United States. The consumption for the last five years--2005, of course, is still current--the mean consumption in the United States is 20,000 metric tons of titanium metal. This is the domestic production from United States mines. It's about 13,500 metric tons. The total weight of titanium as we discussed is 38,000 to 50,000 metric tons. That will be installed and manufactured over approximately a 10 year period. This amounts to two-and-a-half years of annual domestic consumption. It's not going to shut down consumption or absorb all the consumption; it's going to make a major dent in domestic consumption of titanium. The total is about three-and-a-half years of domestic production of titanium. This is going to be a major impact on the titanium market and supply in the United States and the world. When we first heard about this business, everybody said, well, go out and buy ASARCO stock and it's going to be a hot item at that time.

Next one, please? Where does titanium ore come from? Titanium has two major uses. The primary use for titanium is titanium dioxide white pigment. Most paints that we use are based on titanium dioxide. That's probably half or more of the titanium consumption in the world. The rest of the titanium goes into metal production for aerospace and structural uses. The largest suppliers of titanium in the world are South Africa, Australia, and Canada. The United States is the purple field at the upper top here. We're a little minor player in the world market of titanium. China has become a major importer of almost all mineral commodities in the last four or five years and that's going to continue. And, they are consuming a lot of titanium now rather than exporting it. That's going to be a significant factor in the future.

KADAK: What's the world production of titanium?

KENDORSKI: That's a difficult number to come up with. We have the ore production. We don't have the metal production because a lot of countries restrict that information.

Drip shield installation, we install just prior to closure and before retrieval if retrieval ever happens. Minimum of 50 years after first waste emplacement will be installed. And, possibly a 100-year, 300-year preclosure period while the waste packages wait for drip shields to be installed. This environment is going to be 50 degrees Centigrade and the last information I have 122 degrees Fahrenheit. Not bad; I've worked in 140 degree environments underground. It's going to be radioactive which I don't work in. Ventilated, but overall 15 cubic meter per second airflow. That's overall. But, you've got the waste packages that are going to be in the way. So, you're going to have at-ease and turbulent flow in the drifts. And, likely very dusty environment.

The drip shield transport gantry is not the biggest piece of equipment in the project. The waste package transport package is a very large beast. This is a very large beast, itself, though. It operates in a radioactive environment at 60 degree--or 50 degree Centigrade, I'm sorry;

that's a typo there. Remotely controlled by operators on the surface, self-propelled by 750 volt DC electric motors on each wheel from the third rail electrical source system. Moves on steel rails, weighs 45 metric tons, almost 50 tons, and is difficult to recover if it's inoperable in the drift.

Next one, please? This shows the tight clearances. This is a drift envelope. We've got a matter of inches here in this design in this corner. Another possibility is corroded steel rails after 100 to 300 years, difficult to detect, and a dusty environment. It's going to be difficult for these optics to work in.

Okay. This has since changed, but who knows, it may come back. This is a former pin arrangement, but it's not that different than the ridges and upsets in the interlocking system now. The idea here is that this has to be done remotely in a difficult environment and the tolerances are pretty tight.

Next one, please? The connection pins are locking. It's primarily intended to lock shields together mechanically to minimize separation during shaking from major seismic events. The pin connection is conveyed by the drip shield gantry by remote control, a dusty environment, and a very tight clearance envelope. No feedback mechanism instrumentation for verifying that successful interlocking has been obtained has been described. I think there was a brief mention of it in yesterday's presentation, but nothing has been detailed on how this is going to be verified.

This shows the mating of drip shields and the pins. Unsuccessful is a difficult problem here with the clearances we've got. This gets misaligned. It probably should be shown at an angle rather than an offset. This is a difficult problem in this environment.

The tolerance with a pin connection in my brief review of the new locking mechanism, the ridge mechanism, it's a 1.2 degree longitudinal angular tolerance of--you can be off by 1.2 degrees, no more. That's pretty tough to do in this environment and this type of equipment.

Dust, numerous studies in industrial, mining, and military environments have demonstrated the difficulty of operator visual recognition in degraded visibility environments such as dust. And, NIOSH, the former Bureau of Mines, has a major research program in this area how to have operators work in dusty environments. Dust gets in the way of sight, it blocks your vision. It gets lit up by the lights blocking what's beyond it. It coats lenses and gets into the equipment.

Here's a picture I took on October 28th last in a stone mine in Indiana and this was a--why I even bothered to bring a camera in, usually I don't even bother because you can't see anything except for when you're right up to it.

This is a picture looking from about 50 feet away of a piece of equipment that is scaling the ribbon roof of the mine. This is what my camera ended up showing because all the dust is in the way. Very typical of what we have to deal with underground in an active mine. This mine is a damp mine, but as soon as this thing started operating, it started kicking up dust everywhere.

This is from an advisory committee on nuclear waste meeting from February of 2001. They're discussing, obviously, the conditions in the repository at the closure period. Let's just continue on. They're commenting that there may be as much as 300 years worth of dust accumulated before closure. And, noted from their observations in walking around the existing facilities, they would start out clean and end up covered up with dust. This is my experience underground almost universally. The excavation operations, drilling operations all generate dust. The rock itself will generate dust with each change in temperature and humidity and air pressure. Weather systems move in, the rock kicks off a little bit of dust. One mine I worked in in Illinois, a limestone mine, had dust six inches to a foot on the floor strictly from the atmospheric effects.

This is one for retrieval. It requires innovation and equipment development for a very difficult underground environment. I worked first on retrieval about 1978-1979 for the Nuclear Regulatory Commission. I used to use this cartoon a lot at that time. It shows an alchemist, 13th or 14th century, in his workshop with a fully modern television set explaining it to his colleague, "But then I realized in order to make it work I'd have to have a socket and God knows what else." Just because you can conceive of something doesn't mean it's going to be easy to do. And, this is from "Magazine of Fantasy & Science Fiction".

Emplacement drift retrieval environment. After it was sitting for 50 plus years, it's 50 degrees Centigrade nominally. I believe I'd probably be experienced on that. A radioactive environment, ventilated at 15 cubic meters per second which is when the airflow is going to carry dust and you need to talk about filtering this airflow. The airflow will have dust in it because of the spacing of the waste packages or configuration in the drift. There will be turbulent flow and at-ease and low spots that will drop the dust out of circulation. It's a very dusty environment. You're likely to have corroded steel or copper electric third rail. There's going to be copper in this drift at the third rail or possibly mild steel. The rails are certainly mild steel. So, we've got a potentially corroded environment, as well, for power distribution and for transport.

This is the emplacement gantry and retrieval gantry, dual function. Remotely controlled, operates in a radioactive environment, in a 60 degree heating temperature environment, self-propelled by 750 volt DC electric motors on each wheel on steel rails.

This shows a problem similar to the drip shield gantry, very tight clearance system in the envelope of the drift. One thing I have not had a chance to fully investigate is the creep closure of the rock mass surrounding the drift that proposes the drift. Those 300 years, that's going to deform. I don't know whether it's been considered if it's going to deform sufficient to allow these clearances or the modification of equipment or the internal environment is going to have to be made.

I made a flow chart up, just too busy to put in here. But, at least, 23 distinct steps starting with drift inspection, verification conditions through getting the waste package out to the surface in order to achieve retrieval.

It's a pretty complicated situation.

Okay. The project, meaning Yucca Mountain Project, has identified abnormal scenarios; derailment of an emplacement gantry in an emplacement drift or a retrieval gantry, rockfall or emplacement drift major ground failure. I just don't want it to happen on a Monday morning.

Remember, these scenarios have to be dealt with and successfully accomplished in a very difficult environment of long time periods intervening since the last series of people living there. High temperature radioactive ventilation with dust coming in, tight clearances, dusty, settled in the ground, probably corroded power systems, and rail systems.

Okay. This is the best depiction I could find in a project document of an abnormal retrieval scenario of a derailed gantry in the emplacement drift. However, on the right, you see the other view. If this gantry has been derailed in that fashion, it's going to hit the wall and be damaged itself and damage the drift supports. This thing is not a light piece of equipment. So, I think, moving at 50 miles an hour is going to be walking at walk speed, but it's going to have enough momentum that it's going to damage itself and the wall if it derails.

Okay. A large ground collapse, this also comes out of the same project document showing a gantry or waste package. It's trapped by a major roof fall in an emplacement drift in the tuff. This is what's usually depicted in the documents I've been finding, the most current ones.

Please, next one? My experience underground in hard rock, this is what's actually going to happen. You're going to get a widening-out collapse of the roof and surrounding rock and because of what's called bulking factor, blocky rock such as tuff, bulk out to 30 percent to 40 percent of their volume when just aggregated and made into blocks. This is going to fill until the bulk rock support is failing, too. This is my experience in almost all underground opening failures which I specialized in in my practice. What's going to happen, it's going to block the ventilation. There's a very serious problem with hydroelectric tunnels and it blocks your ventilation and your water flow.

Next one, please? Okay. Here's the consequences of a major ground failure. Buried waste packages or gantries, blocked air flow, your heat is no longer dissipating, dangerous radioactive environment, rising temperatures. Tunneling in from adjacent drift or raised boring up from the ventilation level will be slow and difficult and final connection will have to be done remotely. Almost all of this has to be done remotely. This is where that cartoon comes in. If you invent the equipment to do all this, it doesn't exist.

Okay. Common problems to both the drip shield emplacement and retrieval. They're repository locomotives. This is not a show-stopper. They're constantly read in the project documents that the 50-ton class electric locomotives are what's going to be used. And, Improvement Equipment Corporation is cited as a source of these. They have never made a 50-ton locomotive. And, also, they no longer exist. They were liquidated and went out-of-business about five years ago. There's no non-coal rail-haulage mines in the

United States that we can find. All operators have switched to continued belt haulage or trackless haulage. Even Henderson Molybdenum Mine in Colorado which had an 11 mile long haulage tunnel under the Continental Divide switched out to a belt conveyor a few years ago. Pretty awesome to think about, an 11 mile long belt conveyor, but that's what everybody is going to.

Next one, please? Mining locomotives. The Yucca Mountain Project is probably the last market for heavy-duty mining locomotives. The only place to get them is Sweden by special order. That doesn't mean you can't get it. Like most equipment, it's all special order, special design, but it's not an off-the-shelf product. It never was an off-the-shelf product. Goodman has never made a 50-ton locomotive, another chief engineer now retired.

Next one, please? The retrieval locomotive, is has to go beyond the doors, the sealed doors, shielded doors, is hinted at being a 750 volt wet cell battery locomotive. 750 volt wet cell batteries don't exist. Above 300 volts, cell-to-cell arcing and creep occur. I tried to find a greater than 360 volt DC wet cell battery and you can't. The fuel cells and other technologies of these power levels are still in the very developmental stage. In Canada, I think, there's an 8-ton locomotive that works on fuel cells. You can run a 750 volt locomotive with a 350 volt battery which operates slow and with much less power. It won't be able to achieve its cycle times inner-plant. A wet cell battery discharges rapidly above 60 degrees Centigrade due to the lead-to-lead oxide chemical reaction that creates the power for the battery. That rapidly accelerates and the battery would completely discharge in a very short time.

Okay. Drip shield issues wraps us up. Titanium supply, achieving the drip shield interlock.

Next one? Retrieval issues. Retrieval under realistic expected environments needs to be looked into. Manipulating derailed gantries and other vehicles in tight clearances. Recovering waste packages from ground failures in tight clearances. Clearing ground failures remotely. Blocked ventilation causing heat rise before recovery and retrieval. Once that (inaudible) is blocked, the clock is running.

Common issues are the availability of locomotives, availability and performance of locomotive and batteries in this environment, steel rail corrosion, third rail corrosion and remote controlled optics and equipment operation in a dusty environment.

Okay. If these operations are integral to safety and licensing, there must be an up-front and credible plan and design using currently available technologies for how they are to be accomplished. We do not see such plans and designs in the project documents.

Okay, thank you.

GARRICK: Thank you very much, Frank. I think that the Board benefits a great deal from presentations such as this. I think on of the pieces of information that we don't get enough of is operational information and we'd like to very much see similar kinds of discussions and presentations having to do, for example, with the surface facilities. I'm sure we would run into some of the same kinds of problems.

Are there questions from the Board? Andy, do you have a question?

KADAK: It was good. It was certainly good.

GARRICK: All right. Thank you.

All right. We have now come to the point where they have asked to make public comments. There were a couple of questions before we get into the public comment statements that were given to us during the performance assessment presentation. I see that we still have the two presenters here. So, I'm going to raise those questions and they can comment on them.

The first question. If we assume the new EPA standard of 1,000,000 years as adopted, what would the southern extent of the hydraulic hydrologic system performance model be extended to? Do you understand the question?

ANDREWS: This is Bob Andrews. If the EPA standard is adopted as it's currently written, I believe the location of the reasonably maximally exposed individual has remained unchanged and I think EPA discussed that yesterday morning. In other words, there is not a change in the compliance point or the compliance expectations and that the reasonably maximum exposed individual would still be at, for purposes of evaluation of this dose during the time of geologic stability, would still be at that 18 kilometer boundary, if you will. And, the characteristics of that individual would be the same as the characteristics used in the 10,000 year assessment of performance. So, there would be no change.

GARRICK: Okay. We've got one more here.

The question is isn't it more conservative to have the water dry and re-wet rather than just staying wet with a continuous wet film; that is buildup of salts or corrosive materials?

ANDREWS: I'm going to have to lean on Dr. Hardin again, but maybe he left. No, he is here. I presume the individual is commenting on the in-package type environment. And, the main issue of wetness, if you will, or water film continuity is with respect to a diffusive transport. It's not an issue really of the alteration of the fuel or alteration of the in-package materials. And, given that it's mostly a transport mechanism, were it to be "dry" as this question is asked, it would reduce the diffusive transport of any radionuclides. So, whether that dry and then wet and then dry, which could happen, I suppose, it would not change the diffusive characteristics through when it is wet. So, I don't think it would have much of an effect. But, maybe there's something more behind this comment that I'm not quite understanding.

GARRICK: Okay, thank you.

VAN LUIK: John?

GARRICK: Yes?

VAN LUIK: This is Abe Van Luik, DOE. Bob gave the exactly correct answer in the TSPA. I think the person that asked the question should know that we continue to be involved with both Inyo County and Nye County in studying the regional setting. So, we are not totally unmindful of the need to know more. Thank you.

GARRICK: Thank you.

All right. Let's allow some time for the comments. The first one on this list is Dr. Jacob Paz. Is he here? Will you introduce yourself?

PAZ: My name is Dr. Jacob Paz. I'm going to make three brief comments. First, for yesterday, I spoke to a member of the Board and on the afternoon presentation very clearly did he not include in the matrix the effect of sulfate which will be found in Yucca Mountain and their effect on corrosion.

Second is my comments for today on the total performance assessment and I'm going to read a statement which I wrote. "In order to assess the public health associated with the behavior of radionuclides and heavy metals in the environment, knowledge of the partitioned coefficient of each radionuclide in heavy metals between different phases is required. The YMP performance assessment did not consider the competing effect of radionuclides and heavy metals; why? While sorption properties of individual radionuclides or heavy metals may be known mostly in the near-field, variations in these properties when two or more radionuclides and heavy metals are present have not been investigated. And, therefore, heavy metals such as Ni, Cd, and molybdenum will migrate from the site first and be partially absorbed within the near-field, but some will ultimately reach the far-field. This limits the number of soil binding sites and subsequent radionuclide sorption. Furthermore, the EIS stated that sorption parameters measured for one single radionuclide are applicable to the case where more than one radionuclide is present. Competitive effects are assumed to be negligible. This requires confirmation defined near-field and far-field conditions. Can the DOE provide appropriate range scale data to justify their assumption?"

I'm going to write to the Board and request that the DOE will address it scientifically through the coop agreement with UNLV and Weisman Institute which have this.

Last, it's a letter which has been sent to EPA by Dr. Les Braby. "I'm a research professor at Texas A&M Nuclear Engineering Department. Among other things, I developed the first single particle microbeam irradiation system for studying biological consequences of low-level of ionizing radiation. A colleague in Nevada, Dr. Jacob Paz, contacted me concerning possible consequences a bystander felt when cells had been stressed by exposure to elevated levels of heavy metals such as chromium, nickel, and depleted uranium. He is particularly concerned because large amount of such metal will eventually enter the environment. from Yucca Mountain. In my opinion, there is a significant chance that the effect of radiation and heavy metals will not be a simple additive at all exposure levels."

Thank you.

GARRICK: Thank you.

PAZ: I will send you a copy.

GARRICK: Our next commenter is Charles Fairhurst if he's still here.

FAIRHURST: This microphone?

GARRICK: Sure, either one. Whatever you're most comfortable with. You get to lean on that one.

FAIRHURST: Thank you very much, members of the Board.

I just wanted to make a couple of comments on the presentation by Frank Kendorski. Just by way of background, I'm a Professor Emeritus from the University of Minnesota in rock mechanics and I was trained originally as a mining engineer. My very first job underground was a ventilation engineer. I also should mention as a contemporary of Ray Weimer on the ACNW and you saw a quote from those meetings concerning dust, let me say, first of all, about that discussion. I think it was very much concerning. Ray Weimer is a chemist and he's very much concerned about things like dust deliquescence and the sort of discussion that we were having yesterday. I don't think he was talking about any impairment of visibility in an operating mine. I'm sorry, that's slightly out of context.

The second point is mentioned in the great dust problem and quoting 15 cubic meters per second of air movement. That corresponds in that tunnel to about 1 meter per second which is about three miles per hour. It is the same velocity approximately as exists in the current tunnels. And, anybody going along there will see the level of visibility that you can have.

So, if I want to quote somewhat to the other side of the spectrum, say that those velocities are very similar to what you see in the typical metro system, and the underground visibility, you well-know, what it gets to in the underground metro system. So, I think it needs to be put into context. Yes, it is dusty. Dust is everywhere. There's dust in this room and it settles on things and one has to clean things and make sure if you're relying on visibility that you have clean systems to operate them.

The second one which was the question showing major groundfalls of rock in the tunnels during the drip shield emplacement and so on, I think, as far as I can tell, Frank, that drawing that you have is quite old. And, if one looks at current designs, recently a couple of years ago, the design support system for the preclosure tunnel is a continuous 360 degree lining of stainless steel, a Banolt (phonetic) type system with rock bolts. And, it's very hard for me to imagine how you could get the kind of rockfall that was shown by Frank in that system. I was shown, I think, similar ones that have been found by analysis and the consequences of a seismic analysis in the post-closure environment when it is assumed that all the support system has deteriorated to offer no resistance. And, these are very different systems. Preclosure, we have an extensive support system. It's very hard for me to imagine how you would get that kind of design to carry loads if there was a seismic disturbance which was shaking everything down. It would be shaken down onto the top of the support system and not through it.

So, I think it's important to, at least, take these things into context. And, when I see a saying like "most likely ground failure", I think that's slightly misleading.

Thank you very much.

GARRICK: Thank you.

Mike Anderson?

ANDERSON: Hello, again. I'm Mike Anderson. I work with BSC and I manage waste package ancillary component design. During the final presentation, there was a question from the Board about titanium capacity worldwide. As you can imagine, the project often talks with titanium vendors including Timet and Alleghany Technologies. Recent conversation held by one of my colleagues with the folks at Timet said they estimate world capacity at about 50,000 metric tons a year of titanium. In the titanium business when they do amounts, they're usually recycling about half of that inventory. So, that would be metal production of 50,000 metric tons a year at present capacity just to give you some more information on that.

GARRICK: What would you think the procurement rate would be? You wouldn't buy it all in one year, of course.

ANDERSON: No, you wouldn't buy it all in one year. If you assume on the baseline it takes about 23 years to emplace, there's probably--if we follow the waste package procurement model, if you will, there's probably multiple vendors. I think that the presentation assumed, I think, about 10 years of procurement. It would really depend on the economics of that, the number of available vendors, and things like that. Because the drip shields are emplaced out there near the end of emplacement, I don't think a lot of thought has been given to those particular economics from the dynamics of acquisition of those.

GARRICK: Okay, thank you.

ANDERSON: Okay, thank you.

GARRICK: All right. Dr. Azel Topi?

TOPI: Well, on behalf of the Las Vegas Paiute Tribe, we welcome you again here in Las Vegas, Nevada, and come back again and I wish you the best of luck in your travel and your business meeting and so on. That's the chairperson point.

Here's one point I think I'd like to say to the DOE from the history. There was all these nice physicists and the chemists sitting in a room talking about the (inaudible) and Rutherford and Einstein and all these guys. And, there was this young guy stood up and he was talking about particles and all these other things and the physics. And, after he finished two hours of presentation, a fellow in the meeting by the name DuBois--I don't know if you know him or not or heard about him; he was another physicist and a chemist, famous in that time of the year--he said, Shroedinger, instead of you talking and waving your hands, why don't you put all these things in equations? And, you know what, Shroedinger published in a year six papers. Now, we call it the wave functions and the wave equation that he started, the quantum mechanics and the quantum theory we all know about.

Today, we know, for example, that you are here, and before you come here and before you are made by whoever made you, we had to have the hydrogen and the proton and all these other things. So, I think the DOE listening to this conversation, we need all these, call it, equation data. Convince us. I have not been convinced so far with all these beautiful unsaturated, saturated chemicals and models and all that. I want to see one day before I die that I can take an example and learn from one to 10. I'm going to add one plus one equals two, or two plus two equal four. I want to see you in your model instead of talking about all those things, give us an example. We learn from example. All I get is probability things. Give us an example. How do you produce all these things in such a way that I can take it to my wife who is a physician and doesn't know anything about that and I say, honey, here it is. I can convince you of that. She will vote for you. But, give us that little food to chew on.

Thank you again for coming. Have a good lunch, have a nice trip home, and we look forward to seeing you maybe in Christmas stocking. Just kidding. Thank you.

GARRICK: Thank you. Thank you very much.

Steve?

FRISHMAN: Steve Frishman, State of Nevada. Since I wasn't here yesterday, I have to give the benefit of something I--my thought on something I heard today. In Chris Kouts' presentation, you seemed to be fairly interested in how the total system model works and appears to have, at least, gotten on the way to working in directions that you think are beneficial for management of a very, very complex program. Now, what Chris gave you was how the program worked up until a month ago.

Now, with the new approach that we first heard of in early October primarily aiming towards a multipurpose canister, I think it's worth kind of looking at this model for a couple different reasons. First, you have to remember that a technical reason for why the multipurpose container went out of business in about 1995 was because it was at that time--and I think maybe at the current time--not easily compatible with the actual mechanics of thermal loading meaning planning how you're going to accomplish thermal tailoring and loading. So, there was a technical reason why the MPC was sort of out of the system. Of course, there were some other reasons, too, but the technical reason, I think, is one that should be of concern to you.

Now, the reason I'm bringing that up is because you see the total system model as maybe a good tool. I think, it's best that it just be looked at as a tool. So, now, a tool is only as good as the inputs that you have. Now, what's different between what Chris has put it to work for, so far, and what it would go to work for in the context of a multipurpose container is that the way it worked as presented by Chris is the unit is the tool assembly. Under the new approach, the unit would be the multipurpose container regardless of what's in it.

And so, what I sort of envision having to happen is Chris and his people are going to have to learn how to build and operate this tool backwards. What they're going to have to start with is the requirements for thermal management, whatever those might be that they're going to put on the repository, and work all the way backwards to the fuel assembly where the last time you see it is when at the reactor it's put in with a whole bunch of other fuel assemblies, none of which have any constraints on the thermal output. So, DOE is in a position where using the multipurpose container, it's going to have to take whatever it gets and carry that all the way through the system to where it may or may not be compatible with the tail end requirement which is thermal management.

So, this comes back to something that I sent to the Board, I think, probably when the multipurpose container first became an issue in about 1992. I suggested that there was a possibility that the multipurpose container was, one way or another, going to be involved in the extent to which you can achieve the desired safety in the repository. And, desired safety in this case is, at least, according to the way DOE is operating its performance assessment, is at least, in part, strongly connected to thermal management.

So, I just suggest to you that if you want to kind of continue to follow this total system model which I saw some interest in, then it would be worth sort of following how they try to use it in a system that is almost the exact inverse of the way they have already used it. See if you can start it and run it backwards remembering that the unit now is the unmanageable multipurpose container as opposed to manageable individual fuel assemblies. Something to think about.

Thanks.

KADAK: Can I just comment?

GARRICK: Sure.

KADAK: Just a correction, I think. This is Kadak. The objective would be if MPCs were to be used was to load it at the reactor in concert with the thermal management plan, as you suggest. Now, this may or may not be possible. The degree to which it is possible will be determined based on what's in the fuel pools that exist in reactors. So, I think the idea is, you're right, if it can, but the loading is based on what can go right into the repository into the waste package overpack. So, that is the plan. Otherwise, you know, going through the trouble of making an MPC and then having to unzip it when you get to Yucca Mountain and then blend it again, that doesn't make any sense.

FRISHMAN: Right. And, what is behind my view of what's in the MPC is the Department of Energy has no control over what goes into the MPC and--

KADAK: No, but they would have--no, that's not correct. They would have to specify what would go into the MPC if--

FRISHMAN: That's not what the contract says.

KADAK: Well, again--

FRISHMAN: And, also, you have planned sites where more--and you will continue to have more and more of older fuel in container--in dry containers and they're going to be the last things to leave the repository--or to leave the reactor.

KADAK: That's true.

FRISHMAN: Because they've already spent the money. So, take advantage of it for as long as you can and cut down your operational costs in the pool. So, the point is that the Department has no control over what goes into an MPC unless the owner of that fuel for some reason finds that his sharp pencil says that he can give DOE what it would like to have. Other than that, the Department gets whatever the plant gives it. That's why the issue came up the first time and the technical reason why the MPC was not consistent with the thermal management plan and that's because the Department had no control over the thermal input that came to them. And, if you look at, what is it, Page 19, in Chris' handout, you can see that there is some type of a--even in his old system, meaning more than a month ago, there's a peak in how much is in storage. Now, this diagram will change drastically with a multipurpose container and I think that it's possible that the end point, given that you don't know what you're going to get, the end point is that that peak is going to be a great big flat peak and you're going to end up with a default below boiling repository which I'm not saying is a bad thing, but I think you need to know that on the way in rather than as a default. Something to think about.

GARRICK: Thank you very much.

Are there any other comments that anybody would like to make at this point? Judy?

TREICHEL: I'm tired. I've been back and forth across the country several times within two weeks.

Judy Treichel, Nevada Nuclear Waste Task Force. The only thing I would say at this point is I find it absolutely amazing that one of the things that the Department now apparently appears to be looking for is a reducing environment where three or four Secretaries of Energy ago, we certainly wished that they had gone back to the Secretary and said we've taken a look at this gift you've given us which is Yucca Mountain which is unique because it's in an unsaturated environment and we don't think that it has all of the great stuff that we were hoping for. We might have a better deal if we actually were in a saturated zone and had a reducing environment like the rest of the world is looking at. I mean, I think it's really interesting now that they're finding that as being a real plus and sort of looking at the facts on that. That's it.

GARRICK: Thank you. All right.

KADAK: Can I just ask how many members of the general public are here?

(Pause.)

KADAK: Four, five? Thank you.

GARRICK: All right. Well, we've come to near the end of our meeting. I want to thank all the presenters and the briefing people for an outstanding job. I think we stuck to our schedule very effectively and that's because the presenters allowed the Board the time it wants to ask questions and I'm very pleased.

I think this meeting was an excellent meeting. We heard some new material that we probably didn't expect to hear. We have lots to do in trying to decide where we go from here with that information, but we're very grateful for the involvement of everybody and the participation and we want to thank you very much.

And, unless there's comments from a Board member or a member of staff, we will call the meeting adjourned at the present time.

(Whereupon, the meeting was adjourned.)