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NUCLEAR REGULATORY COMMISSION

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COMMISSIONERS MEETING WITH THE NUCLEAR WASTE TECHNICAL REVIEW BOARD (NWTRB)

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THURSDAY, JUNE 14, 2001

The Commissioners met in the Commission Hearing Room at One White Flint, Rockville, Maryland, 15 10:00 a.m., Richard A. Meserve, Chairman, presiding.

PRESENT:
RICHARD A. MESERVE, Chairman
GRETA JOY DICUS, Commissioner
EDWARD McGAFFIGAN, JR., Commissioner
JEFFREY S. MERRIFIELD, Commissioner
KAREN D. CYR, General Counsel
ANNETTE L. VIETTI-COOK, Secretary
JARED COHON, Chairman, NWTRB
DEBRA KNOPMAN, Member, NWTRB, Senior Engineer, RAND Corporation
DR. ALBERT SAGUES, Member, NWTRB, Distinguished University Professor, University of South Florida

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P-R-O-C-E-E-D-I-N-G-S

(10:01 a.m.)

CHAIRMAN MESERVE: Thank you, Madam Secretary. Commissioner Diaz asked me to explain that an urgent matter has come up this morning that requires him to attend to, as a result he's able to participate and he asked me to express his regrets.

We're meeting this morning to hear from the Nuclear Waste Technical Review Board on the status of its reviews of the Department of Energy's activities concerning a potential repository at Yucca Mountain. As I think everyone in the audience realizes, the Review Board is an independent advisory body that was created by the Nuclear Waste Policy Act amendments of 1987.

This meeting is particularly timely. DOE has issued is Science and Engineering Report very recently and that, along with other information, will be used by the Secretary of Energy in considering the possible repository at Yucca Mountain and also within the last 10 days or so, the Environmental Protection Agency has completed its final standards for the repository at Yucca Mountain.

Consequently, this will be a very busy period for the Commission as we deal with evaluating the report and with conforming our regulations to the EPA standards as we're required to do by the statute.

We monitor the activities of the Review Board and are very interested in the insights that you have to provide. I know that you have provided advice and met with the Commission on other occasions and we very much look forward to further interactions with you this morning.

If we have no comments from my colleagues, Dr. Cohon, why don't you proceed?

DR. COHON: Thank you, Mr. Chairman. My name is Jerry Cohen and I am the Chairman of the Nuclear Waste Technical Review Board. With your agreement, Mr. Chairman, my colleagues and I will summarize our written remarks that were submitted to you in advance and do so relatively quickly so we can get to questions and discussion.

I'm going to focus on some background information about the Board and I'm going to call on my colleagues to say more about it.

First, let me a little more about myself. As is the case with all of the Members of the Nuclear Waste Technical Review Board, we are part-time special government employees. We all have other jobs. In my case, I'm the President of Carnegie Mellon University in Pittsburgh. Debra Knopman is with me today. She's a senior staff person at the RAND Corporation, having joined RAND after many years with the federal government, primarily with USGS. Her expertise is in hydrology and systems techniques.

We also, I'm joined today as well by Albert Sagues. Dr. Sagues is a distinguished university professor at the University of South Florida. His expertise is in corrosion and also materials and a variety of other related matters.

We're very pleased to have this opportunity to brief the Commissioners. It's been a while since our last visit. In fact, Mr. Chairman, I think it's the first time we've had a chance to brief you since you became the Chairman. We're very pleased to have this chance to do so.

Drs. Knopman and Sagues will focus on key priority issues that the Board has identified over the last year. Let me, before they do that, give you a little more background on the Board, expanding a bit on what you said, Mr. Chairman.

As you noted, the Board was created by Congress in the amendments to the Nuclear Waste Policy Act of 1987. That's the same act that designated Yucca Mountain as the only potential site for a possible repository to be studied further. In setting up the Board, the Congress stressed the importance, in their view, of having an independent federal agency to provide review of the scientific and technical work that DOE would be undertaking with a focus on Yucca Mountain, but not exclusively to Yucca Mountain, were also charged to look at other aspects, other elements of the nuclear waste management system, including transportation and packaging.

All the Members of the Board are appointed by the President from a list of nominations submitted by the National Academy of Sciences, as specified by the law. The 11 of us represent the various disciplines that are relevant to nuclear waste issues. I forgot to say what my own interest and background is. I'm an environmental and water resources expert with a particular interest in systems techniques.

One of the important aspects of our work and one that should be emphasized is that the Board strives to follow DOE's work as it's unfolding. We generally don't wait until a final copy of a report or a study is done. We try to get updates and DOE is very cooperative in providing us data information while the work is on-going. This is important so that we can comment while the work is still on-going and therefore influence it to the extent that that is called for. And as I said, this works quite well. DOE cooperates.

The Board is obligated to, by the law, to report to the Secretary of DOE and the Congress at least twice a year. We do this in a variety of ways through written reports, through congressional testimony. In addition, the Board has organized itself into several panels and those panels are organized around specific themes or issues that arise and these panels meet from time to time, not on any particular schedule, but as the need arises. And indeed, two of our panels, we're having a joint meeting next week in Las Vegas to focus on some key and timely issues.

As you noted, Mr. Chairman, the intensity of the nuclear waste issue is growing and this is already an intense time and we expect that it will even increase over the next several months as DOE approaches its announced likely schedule of announcing their site recommendation by the next calendar year. That will be a key milestone. There have been others, of course, that DOE has passed, via the assessment which they issued in 1998. Site recommendation documents are starting to arrive as the Chairman noted and as I just said, they're focused on the end of this calendar year to recommend the site or not.

That will be a key time, of course, in the history of this program and a key time for this Board as well because the site recommendation decision is one that the Board was, in fact, created to focus on in a very significant way.

Each of these milestones is important in its own way. How important it is probably depends on the person you ask and what's happening at that moment, but as I said in our view, this site recommendation is a -- will be the most important milestone to date in the history of the program.

As I mentioned before, the Board identified key priority areas, four to be exact, over the last several months. And Dr. Knopman will now take over and brief you on those priority areas.

Debra?

DR. KNOPMAN: Thank you. Really beginning in January of 2001, the Board began to identify publicly these four priority areas. The first is meaningful quantification of conservatisms and uncertainties in DOE's performance assessment. The second relates to progress and understanding underlying fundamental processes involved in predicting waste package corrosion rates. The third has to do with the evaluation and comparison of the base-case repository design with a low temperature design. And the fourth relates to developing multiple lines of evidence to support the safety case for the proposed repository.

Let me just talk a little bit about the quantification of uncertainties. Meaningful quantification of the uncertainties associated with performance estimates really enables policy makers to make informed tradeoffs between projected performance and uncertainty in those projections. That's why the Board has been so focused on this. The Board is encouraged by DOE's

efforts this year, but we also have cautioned that additional efforts are needed before a case can be made that uncertainties have been estimated in a technically credible manner.

The further point that the Board has made relates to the difficulty of determining the overall level of conservatism when you have a mix of conservative realistic and optimistic assumptions, as is currently the case.

If DOE believes that a performance assessment is conservative, then we think an effort must be made to provide a defensible estimate of just what that level of conservatism is.

The Board, of course, recognizes that eliminating all the uncertainties associated with performance assessment at Yucca Mountain will never be possible although they can be reduced in certain instances. Further, a decision on whether to recommend the site can be made at any time, depending in part on how much uncertainty is acceptable to policy makers.

The Board believes, however, that developing methods for quantifying uncertainties in the DOE's performance assessment should be a priority because of its value to decision makers and its contribution to technical defensibility.

At this point, I'd like to turn the mike over to Dr. Sagues who will discuss the Board's concerns with waste package corrosion and repository design.

DR. SAGUES: Thank you, Debra. All right, as you already know, initially when the mountain was being considered for a potential repository, the geologic boundary was expected to be really one of the most effective obstacles between the waste and the surrounding environment.

As time progressed, it became more clear that the performance of the proposed repository would depend a lot on the integrity of the waste package. And indeed, that integrity is degraded primarily by corrosion. That is what is expected to be the main mode of degradation.

The Department of Energy selected a material that we at the Board believe is one of the basic materials available for waste package construction. Now this material relies on this corrosion resistance on a phenomena called passivity and what you do is you develop on the surface of the metal an extremely thin layer. It may be just a few milliliters, maybe 10 to 20 to 100 atoms thick. It's an oxide layer. And that is what makes the package resistant to corrosion. If that thing stays the package resists corrosion, if nothing goes, the corrosion resistance will become undermined.

Now what happens is that from an engineering standpoint, we have been using passive materials for corrosion performance for maybe 100 years or so.

And the particular alloy of which the package is going to be made of, the corrosion resistant part of it, we may only have a couple of decades experience with that kind of specific alloy. And of course, we need to extrapolate performance over 10,000, maybe 100,000 years. And that is an unprecedented extrapolation gap and that cannot be done just by referring to empirical evidence for a certain amount of time, you have to have fundamental understanding to go with it. Otherwise, you cannot extrapolate over a long period of time.

So that indeed has been one of the concerns of the Board. We need that fundamental understanding to be able to make an extremely long-term extrapolation.

There is a number of things that could perhaps happen. People, engineers, scientists have been speculation and indicating potential degradation mechanisms which are not observed at the present, but they might happen over the long term. For example, this passive layer begins to sweep into the metal, progresses over long time periods and it may begin to accumulate defects which are not observed in shorter experiments and so on.

Now the Department of Energy has been working the last few years in trying to improve its level of knowledge into -- about what may be happening with these materials, but we feel that there has to be a strong component of fundamental understanding to go along with that relatively short term experimental bases.

Also the one thing that may be very helpful to provide some direct evidence that this mode of corrosion protection works over long periods of time is to look perhaps at -- to look very hard to be natural analogs. There are some alloys that may have exited in the metallic state over very long periods of time in the passive condition and if one could observe and document that, then one would have yet another way of inquiring the long-term extrapolations and increasing the level of confidence on those.

All right, the other thing that they wanted to mention was our concern with looking at alternative designs in order to again increase perhaps a level of confidence that could exist.

The present base case repository design is what you can call briefly hot design. The idea is to boil the water around the immediate neighborhood of the packages that makes for dry environment that reduces the possibility of deterioration of the packaged materials. And now when you do that you're introducing a number of hydrogeological processes that may be a couple -- for example, the heat may alter the nature of the rock around the package and then they change the way in which the water moves anyway and now we end up with compound processes which are more difficult to predict when you get to higher and higher temperatures.

Of course also, the corrosion severity in many systems with temperature, so that's another thing that will be mindful of when you consider higher operating temperatures.

We feel that to take care of these uncertainties in a relatively short time, like a couple of years, may be very difficult when you're just looking at strictly a relatively high repository design. And maybe looking at the lower temperature design, where maybe the surface of the packages will be reduced, for example, say 85, 90 degree Centigrade or so, that kind of thing may be easier to correct from an uncertainty standpoint. In particular, the Board has indicated that it would be very helpful to see a direct comparison between a low temperature ventilated repository design and the present base case.

Performance analysis could be used to do that, or could be modified or adapted to do that and of course when that has been done, the DOE may want to look at the number of other issues like logistics involved in operating at the lower temperature and the essential ability of that design and

so on. So anyway, that's -- that's the other important area of concern.

I think that Dr. Cohon now should discuss the area of the Board's concerns and make some comments.

DR. COHON: Thank you, Dr. Sagues. My colleagues now have told you about three of our four priority areas of concern. The quantification of uncertainties, further understanding of basic corrosion processes and looking and comparing a low temperature design to the base case high temperature design.

The fourth area is urging DOE to investigate what we call multiple lines of evidence. This goes to the issue of increasing confidence in the safety case for the proposed Yucca Mountain repository and we strongly endorse the DOE's efforts in doing so. In our view, the DOE's safety case rests on key elements or pillars, our word, pillars, not theirs. Those are performance assessment calculations, safety margins and defense-in-depth, potentially disruptive events, evaluation of those events, insights from natural analogs and performance confirmation.

Some of the pillars, and in particular, performance assessment, safety margins and
defense-in-depth and the analyses of disruptive events are all one way or another dependent on performance assessment. Obviously performance assessment itself is, but even these others derive from performance assessment depend on performance assessment.

Thus, we have one last confidence in the DOE's performance assessment and I'm not saying we do, but if one does, one is not likely to have much confidence in the other pillars that depend on it. The last two pillars of the repository safety case, natural analogs and performance confirmation are independent of performance assessment calculations. However, in our view, the DOE's evaluation of natural analogs so far has been minimal and performance confirmation is, in fact, effectively a plan of activities that will be subject to future budgets and time constraints.

Additional development of the multiple lines of evidence supporting the safety case of the reports of the proposed repository is there for a high priority in our view, for the Yucca Mountain
project.

Let me summarize what we've told you by again going back to the four priority areas and just pointing out the key things. DOE has started an effort to quantify conservatisms and uncertainties that had not bene quantified previously. The DOE has started an external peer review of waste package corrosion issues and I should point out the Board has also begun its own review of fundamental corrosion processes. The DOE has developed a low temperature operating mode that can maintain repository temperatures below boiling. The Board remains concerned, however, that a comparison of high and low temperature designs is needed and we urge the DOE to perform that comparison.

Finally, the DOE did participate in a meeting that we held in April on this issue of multiple lines and we appreciated what we heard and we continue to urge DOE to pursue those issues.

The Board will continue to review the technical and scientific aspects of DOE's work at Yucca Mountain and we will continue to issue reports and make recommendations as we see fit. Thank you very much for your attention and we'd be happy to answer any questions that you have.

CHAIRMAN MESERVE: I'd like to thank you all for a very helpful presentation.

We rotate our order in which we do questioning and I think it's Commissioner Dicus' turn to go first.

COMMISSIONER DICUS: Thank you. Again, we appreciate your coming down and giving us this opportunity for the interchange.

Let me to go the issue of quantification of uncertainties. With respect to quantifying conservatism and reducing the uncertainty, could you tell me what more specific recommendations that the Board has made to DOE to better address and resolve this issue. It seems to be improving, but were there specific comments that you would want to make?

DR. COHON: Let me just jump in and say unlike the NRC, Mr. Chairman, we don't have any kind of rotation on answering questions, but I'm the Chairman and I have my colleagues with me, so I get to call on them.

Take it away, Debra.

(Laughter.)

MS. KNOPMAN: What the Board has encouraged DOE to do and they are in the process of doing is going back to the fundamental process models and working with the individual investigators to identify where certain assumptions were made and how those assumptions could be characterized. You really have to go back to basics there. You can't just jump in necessarily at the total system performance assessment model level to be able to tease out where these different assumptions that have different effects on alternate performance have gone.

So the Board has had on-going conversation with the program. They've come to us and asked of our view of whether we thought they were moving generally in the right direction. What's been found is there's bene a very uneven approach taken at the process model level among the investigators as to how uncertainties were dealt with and quantified. And so this is now a fairly elaborate process DOE's involved in, trying to untangle that.

COMMISSIONER DICUS: Does -- do you want to --

DR. COHON: Yes, may I add something to that? I'd like to expand a bit on that. As Dr. Knopman said, DOE has been involved in a very intensive and thorough process of going through submodel process by process and that does come out of one of the recommendations we made, that is to quantify uncertainties.

The other major recommendation made though had to do with how uncertainty is conveyed to decision makers and to policy makers. That's sort of the other part of that and we feel that's terribly important. The NRC and by that I mean Commissioners, the four of you plus Commissioner Diaz, are used to dealing with problems, technical problems characterized by a great uncertainty, but before this project ever gets to the Commission, it is likely to be -- well, certainly will be the subject of review by the Secretary and the President and likely to be reviewed -- the subject of review by the Congress.

People in those positions, I think, deserve and need assistance by the program in understanding the uncertainty associated with whatever the recommendation is. That's not easily done and it requires a major effort. I

think DOE is to be commended for what they have done, both in terms of the quantification exercise that Debra described, but also in terms of their thinking about how they can characterize uncertainty for nontechnical policy makers which must surely do.

I just want also to add here that the Board appreciates greatly what a major challenge this is for anybody. That is, this is a very complicated problem. The total system performance assistance consists of a very large number of models and submodels and parameters and all that is based on a vast array of studies coming up with a good and meaningful quantification of the uncertainties associated with such a model, a modeling exercise is no easy feat. And DOE has made substantial progress.

COMMISSIONER DICUS: Do you have a quantification of some sort what level of uncertainty or certainty, whichever the case may be that you would find acceptable?

MS. KNOPMAN: Well --

DR. COHON: You go right ahead.

MS. KNOPMAN: The Board has said on numerous occasions that it's not for the Board to decide what the acceptable -- socially acceptable or politically acceptable policy, acceptable level of uncertainty is. But that's a judgment to be made in a different forum than the Board, where the Board feels it has a role is in making sure that there is that quantification. So that those who are in the position to make the judgment, will make the judgment based on whatever factors they feel are relevant to the decision.

And in this case, we're dealing with materials engineering issues, natural system uncertainties. It's a very wide range of uncertainties in these various processes, some of which will be irreducible because of just the nature of the physical system. So it would be, I think, inappropriate to try to nail down a single uncertainty standard on any one parameter or process anyhow, but the point here and that's the whole value of a total system performance assessment tool is to try to integrate those various pieces of information into something coherent.

The Board, I'd just add one point on your previous question, the Board's been concerned that you can make a certain set of assumptions which reasonable people would say were conservative in the context of a TSPA, but in the process mask, other uncertainties that may, in fact, be important and you'll never see them or understand them and deal with them if that's not made explicit.

COMMISSIONER DICUS: You know we have the WIPP site, that is operational now. Granted, it's a different kind of waste, a different kind of site. Given those two acts on the front end, have you done any comparisons with how DOE addressed uncertainty between what they're doing with Yucca Mountain and what they did with WIPP?

DR. COHON: My sense is no. But my colleagues may feel otherwise. We did -- we visited WIPP as a Board. We also spent considerable time with the management of the WIPP facility to understand how they handled some of the high level issues of such a project. So in that sense, we've looked at WIPP. I'll take that back. We actually, we had presentations in the past going back fairly far on TSPA as applied at WIPP. And there was some aspects there of how they handled uncertainty, but recently, not in the last couple of years.

COMMISSIONER DICUS: Okay, just two more quick questions if I may, Mr. Chairman. In the meetings that you've conducted in Nevada, are there any insights or thoughts you would like to share with us with respect to concerns that may have been voiced by citizens in Nevada regarding the NRC and the understanding of the NRC's role?

DR. COHON: I thank you for that question. It's -- I'm sincere. I'm not being sarcastic at all. The issue of public participation and public views on Yucca Mountain is one that the Board takes very seriously, though our focus is purely the scientific and technical aspects of the project and we adhere to that.

We nevertheless, always include public comment period in our meetings and I think this has proved to be quite valuable, both to the Board and to DOE who also are present and get to hear public comments.

If there's one thing that has come up with regard to the NRC, I think we've heard from some members of the public and Board meeting records could be checked to confirm this or not, that there's confusion in their minds about what closed pending means and they worry about the substantial interaction between DOE and NRC at this stage, over technical issues.

I think it's primarily a case of simply not understanding what the process is, what the two Agencies are doing when they're meeting together and what some of the terminology means.

COMMISSIONER DICUS: I appreciate that and we're aware of these issues and when we have our meetings out there, I understand staff is trying to address these things. We have benchmarked to see how successful.

Final question, as you have gone along, as you will go in the future making the recommendations that you make to DOE, on technical aspects, on uncertainties, on these four areas of concern that you've expressed, to what extent, as you go forward with a recommendation do you, have you looked at if there is a recommendation for Yucca Mountain and if we do get a license application, as to what our needs might be as a regulatory agency to make a decision if all these ifs happen, that is an if.

Are you looking at what we might need to make that regulatory decision or are you strictly focusing on what you see as your charge for DOE?

DR. COHON: We have focused on our charge and that has -- the focus of that has tended to be the site recommendation before DOE applies for a license.

However, we are certainly aware and the DOE operates in this manner, that much, if not all of the information developed for site recommendation is directly relevant to the license as well. At least we believe so.

Licensibility or license requirements is certainly something that DOE thinks about and we hear about that from time to time, but it's not been the Board's focus. We have not asked that question.

MS. KNOPMAN: Were the Board is by statute to stay in existence until a year after the first waste is in place, if there is a repository, and so we will at some point need to turn our attention, if that should arise, but we've been looking at the next milestone.

COMMISSIONER DICUS: Okay, appreciate your responses. Thank you, Mr. Chairman.

CHAIRMAN MESERVE: Thank you, Commissioner Dicus.

Commissioner McGaffigan?

COMMISSIONER McGAFFIGAN: I'm going to start with multiple lines of evidence and what I know of this I've learned from our Advisory Committee on Nuclear Waste. It strikes me that a good performance assessment and I think it's in our proposed rule, 63114 of our proposed rule lays out what a performance assessment is going to need to do, but a good performance assessment is supposed to capture everything.

That's what Mr. Garrick has tutored me and if we had insights from natural analogs, you said that that might be separate from the performance assessment. If we get insights from natural analogs it's going to play into the performance assessment in terms of model parameters, ranges, the C-22 was talked earlier that there might be natural analogs for the C-22. So in some sense, I've been hearing this for a year. I haven't had a chance to talk to you guys since you made this presentation, but it strikes me it's almost tautological that a performance assessment, if it's good, and it has to capture everything and you ask for lines of evidence separate from the performance assessment is to ask the impossible, if it's a good performance assessment.

So could you explain to me how I'm not -- why I shouldn't be confused?

DR. COHON: We're all eager to comment on this, but it looks like Dr. Knopman is especially eager to do so, so why don't you go ahead?

MS. KNOPMAN: I think your last phrase is really critical and that is if it's a complete total system performance assessment, it's a very, very big if, that's not to say what DOE has done has been substandard in any way. It's an enormously complicated complex model which I'm sure you know and you've got your own version of it.

The question is how much can you capture in that and do you, in fact, draw in other intuition or evidence that is not output from a specific numerical model of some kind. A TSPA, as it is now construction, as DOE uses it, as fed by dozens and dozens of process models which are then abstracted and those abstracted results are put into this larger construct, every time you lift something out of one model and put it in another, you make a certain set of assumptions and you have about wiring that model up. Things get lost on the cutting room floor, particularly the coupling of various processes.

And what you can get in looking at natural analogs, for example, is a kind of an integrated that doesn't have the overlay of sort of human intervention in the sense of how those coupled processes really end up playing out, looking at a mineral like josephinite, you know, is an example where it's bene subject to some kind of weathering and it's in a sense, an integrator in a way that I think isn't appropriate to check on a mathematical construction that TSPA is. So in the best of all possible worlds, you want one super model that really did take in all of that information and I know Dr. Garrick and others are always looking for that kind of level of achievement, but practically speaking, I don't think we're near that yet and that it's appropriate to find these other checks.

DR. COHON: Nor would we ever be. Models are, after all, models.

COMMISSIONER McGAFFIGAN: Right.

DR. COHON: They are representations of the real world. They are limited both by our understanding of the phenomena in the real world and by limits on data. I'm not going to dwell on the model in certain issue and not the data either, although they're both important and natural analogs are important there as well and we can give some good examples, I think, but it's in the nature of this problem that the DOE must project, predict, estimate performance at least 10,000 years out in the future. And they not only have to do that, but they have to produce a compelling case for nontechnical policy makers and decision makers as to why we should believe your projections that this is going to work.

Now corrosion is perhaps the best, perhaps the most compelling example. We've said tongue in check, if only DOE could find a 5,000 year old C-22 coin that was in perfect shape, that would dispel all doubt. It's unlikely to happen.

COMMISSIONER McGAFFIGAN: But if I were arguing from the other side, I would say that that coin, whatever environment you found it in is not the environment it's going to face at Yucca Mountain.

DR. COHON: There's that argument.

COMMISSIONER McGAFFIGAN: So even if you found that coin at the bottom of the sea, well, sea environment is different from Yucca Mountain environment.

DR. SAGUES: I would say it's a little deeper than that. At this moment to our knowledge there isn't a single documented case of a metal that relies on passivity for its corrosion performance. Having been in that condition for extremely long periods of time, that is, you realize, much more fundamental level of question. We are faced with a need to find an example of the mechanism itself working over extremely long periods of time, so you realize that that's -- we're saying just show us something in any environment first.

COMMISSIONER McGAFFIGAN: It still strikes me that there's a bit of a disconnect here. I understand that the models -- let me go back to the -- as I understand the rule that EPA has put out that we're going to align our rule up with, it requires for 10,000 years, not more than 10,000, but 10,000 years the reasonably maximized exposed individual not get more than 15 millirems effective dose equivalent or 4 millirems to any organ groundwater pathway.

And that's a reasonable expectation based on the performance assessment, so the focus of their rule and our rule, in turn, will be on the performance assessment and in the licensing space which presumably is going to be adjudicated if the President makes a proposal, if the Congress agrees, and if there's a license application submitted, the focus of our licensing boards and any contentions are going to be on the reasonableness of parameters assumed in these various models.

I think some of the comments you've made in the past about the transparency of the TSPA, if it isn't transparent not, it's going to be

perfectly transparent in our licensing process because I suspect people are going to go through and challenge any assumption, any range. It's a mean that we're going to be working towards and that's going to be the heart of our licensing process is to challenge every parameter assumption that DOE presumably made that is challengeable and in some way talking to political leaders, part of the check, you know, about the degree of uncertainty that's tolerable and all of that, that's really going to be decided in some degree in the licensing process through the give and take of an adjudicatory hearing where people are going to, not the best way to solve technical issues, perhaps, but there will be technically competent boards and a technically competent commission at the time that will at the end have to make these judgments. But the focus of the EPA rule is on the performance assessment. It's not on -- I suppose that the trial, people can say we've got this other line of argument, but the focus is going to be on contentions related to the performance assessment.

DR. COHON: Right and rightfully so. Don't misinterpret what we're proposing here. Most of us, in fact, are modelers and we believe in modeling and we believe in TSPA or the statement. We think TSPA is a very valuable tool and basing the role on TSPA rather than subsystem requirements I think is completely appropriate, but models have limits. What you just anticipated, your comments in anticipating what the dialogue is going to be like goes right to that point. This model is going to be taken apart and eery piece will be dissected. So let's take an important piece --

COMMISSIONER McGAFFIGAN: You all are likely to be witnesses. I don't know if you thought about that, but you're in existence until one year after this thing opens, I suspect as people who have watched this thing on one side or the other is going to -- depending on which statement you guys have made in the past is going to have you sworn in at these trials. I expect there to be multiple trials. Look forward to that too.

DR. COHON: This is the great thing about having limited terms though.

(Laughter.)

COMMISSIONER McGAFFIGAN: They'll find you. If you think being retired is going to --

DR. COHON: I'm going to set Dr. Knopman up here, I hope. Let's take one piece of the TSPA, a key part in arriving at the estimated dose at the stated distance is the groundwater model, the saturated zone model. We don't know, DOE doesn't know, no one knows just how water will move through the saturated zone. You have to have a model and that has to have some data.

And there is such a model and experts can disagree how believable it is in their view. The question is wouldn't it be valuable to have a natural analog you could point to that either buttresses your confidence in the data, the parameters that you're using or the model that you're using or not or rejects that. That's all we're talking about.

MS. KNOPMAN: Just picking up on that point, there really is an important distinction to make here between parameter uncertainty and model uncertainty. You can do conduct field experiments, lab experiments and refine a parameter estimate to the nth degree and it doesn't mean anything if it's in a model that's probably not a good representation of reality and real issue here is these model uncertainties which TSPA frankly has a hard time grasping.

It presupposes the model is mostly okay and it fiddles with parameter uncertainties. Those are the knobs that get turned. So that's why this multiple lines of evidence point that the Board has made repeatedly is mostly, but not entirely, focused on getting at some of these model uncertainty questions that really are a check, an independent check on the assumptions of the TSPA construction.

COMMISSIONER McGAFFIGAN: If you go to the saturated zone flow that you started with what natural analog will you have that they could research and would help confirm that model one way or the other that's specific to Yucca Mountain?

MS. KNOPMAN: There are certainly other groundwater basins in the Yucca Mountain vicinity where one could trace isotopes, various isotopes and get a better understanding of flow fields. So some of that --

COMMISSIONER McGAFFIGAN: Sort of an experiment you would insert --

MS. KNOPMAN: There are wells --

COMMISSIONER McGAFFIGAN: Yucca Mountain material and look for it to show up?

MS. KNOPMAN: Or you use natural tracers of various kinds of isotopes. That science has advanced quite a bit over the last 10 years. Some of that's been done. They're trying to do that even at Yucca Mountain looking at other chemical constituents, but they have very few data points in the saturated -- in the flow field between the footprint of the proposed repository and the 20 kilometer compliance point.

COMMISSIONER McGAFFIGAN: On the quantification of uncertainties that Commissioner Dicus has already asked you about, I guess hearing you just talk what you're most concerned about are model uncertainties, although parameter uncertainties may be a problem.

You said in your comments it's difficult to interpret performance predictions on conservative, realistic and optimistic assumptions. Could you give us some examples of optimistic assumptions that may be in the current TSPA that you'd worry about?

MS. KNOPMAN: Maybe I'll try on the natural system and Alberto or Jerry could speak to some of the other pieces.

Just take the near field environment around the drifts. It may be optimistic to believe that coupled thermohydrologic mechanical effects are largely negligible during the thermal pulse period which can last up to 2,000 years. It may not be, I don't know, but it's an arguable proposition that that's an optimistic view.

Now there are other conservatisms that the program has introduced in looking at seepage in the near field environment that perhaps offset that optimistic view about the effect of these coupled processes. The difficulty in analysis is how do you know what you end up with in the end when you have something that's possibly optimistic next to something or in parallel or in series with another set of assumptions that are conservative, what's the net result.

COMMISSIONER McGAFFIGAN: I'll just study on this one for a

moment. They do this optimistic assumption with regard to the near field. Can they do a sensitivity analysis, have they already done a sensitivity analysis, say if this assumption that it's negligible is wrong, and something, the worse thing happens do I still meet 15 millirems all pathway or have they done that sort of sensitivity analysis?

MS. KNOPMAN: I don't know of all the sensitivity analyses they've done, I'm sure they have done some on that, but this is a question that they're actually spending a lot of time on right as we speak because there are several different models that are used and coupled. It's not an easy technical analysis to conduct, given their current array of modeling tools right now. So there's not a -- I'm not aware of a simple answer, but we will check on that. I think that's probably the best way to handle that question.

COMMISSIONER McGAFFIGAN: You're probably going to raise C-22?

DR. SAGUES: Yes. One of the issues that is quite critical is whether there's going to water or not in liquid form on the surface of the package and until recently the expectation was that when the temperature was about 125 degrees centigrade, it would be completely dry, but there is evidence coming up in the last year or so that there may be salts deposited on the surface of the package say during the long period of ventilation before closing the repository and the like that may be in such a way that you may end up with liquid water, some sort of concentrated brine, very thin, on the surface of the package. The temperature may be now 130, 140 degree centigrade and as you know, every time you go a little bit more in temperature, the severity of the degradation process could increase.

COMMISSIONER McGAFFIGAN: It's the stuff the drip shield doesn't help against because it happened while --

DR. SAGUES: Right, right, this will condensation from the moisture and it's hard to imagine that there will be condensation at such a high temperature, but if those salts are present it could be and in that sense the assumption that was done a couple of years ago may very easily be too optimistic an assumption.

The other thing will be the composition of the kind of things that will be in that water. There may be substance is present in extremely small amounts in the powder that will end up being deposited on the package surface that makes some nasty surprises and they are at this moment, the assumption is that those substances might not be present and more detailed analysis is increasing -- is leaving one to believe that the chances that those substances may be present is perhaps greater than what was formally anticipated.

COMMISSIONER McGAFFIGAN: Again, this can be created by -- you said this is the stuff that gets kicked up, the dirt that gets kicked up within the repository as things get stuck in it and there's moisture allowed in? I guess this can be treated by sensitivity analysis as part of the TSPA. This sounds like something that you could assume greater degradation of the packages and see whether you still meet the 15 millirem.

DR. SAGUES: I think certainly that could be quantified. The question is whether that gets actually inserted into the models and whether we have enough knowledge or they have, DOE has enough knowledge, to insert it in the right manner, of course.

DR. COHON: Could I just expand one bit. Again, as a modeler I admire TSPA and you can do a lot with models, but they do have limits. You can do a lot by doing these sensitivity studies and these are instances where you can, but if a phenomenon is not modeled adequately in the model, you can do sensitivity analysis until the cows come home and you won't see the effect.

This is precisely why we were so concerned about high temperature, low temperature because these coupled processes, the thermo, hydro, mechanical interactions are not capturing the model and for good reason, because these are new phenomena that we know so little about. DOE is doing studies. They have been doing studies.

They've been doing I think well within their resource constraints, but to date, TSPA does not capture that adequately, so understanding the sensitivity of the repository performance to some of these things you just can't get a very good handle on it.

COMMISSIONER McGAFFIGAN: So the way these all get connected then is that the reason, your concern about some of the uncertainties, model uncertainties in the TSPA leads you to say I can solve a lot of this, these uncertainties largely, some of them at least, largely go away or get reduced to very negligible levels if I go to a colder repository. So that's why these different thoughts are connected in some fundamental way?

DR. COHON: That's right. You put it a little more strongly than we would, but yes, that's the basic gist of it.

COMMISSIONER McGAFFIGAN: Thank you, Mr. Chairman.

CHAIRMAN MESERVE: Commissioner Merrifield?

COMMISSIONER MERRIFIELD: Thank you, Mr. Chairman.

Dr. Cohon, I was interested in following the interchange you had with Commissioner Dicus regarding the interactions that the Board has had with the folks in Nevada and some of the comments about what we have done as an Agency in that regard. I agree with Commissioner Dicus, there is more, in fact, we can do in that area.

I guess I'm also struck by the fact that we perhaps need to repeat more often for our stakeholders out in Nevada the fact that we are, in fact, independent of DOE which some people are not aware of.

DR. COHON: We have to do the same thing by the way.

COMMISSIONER MERRIFIELD: Right, and that at the end of the day if this were to be proposed by DOE, if the President and Congress were to accept that and we were to receive an application for a license, at the end of the day one of the things in our licensing basis is our ability to say no. At the end of the day, all this stuff goes by, the NRC has the right and the obligation if we do not believe that this facility is protective of public health and safety to say no, and I think that's something we sometimes fail to repeat. I don't mean to use your time in that respect, but I think I'd like to have that in the record.

I would like to follow up then on Commissioner Dicus' question and that is along these lines, and we've been trying to think among ourselves, are there better ways in which the Commission can reach out to the individuals who are most highly impacted by this, the residents of Nevada, if this were to move forward and improve our dialogue with them and improve our interactions

and improve our communications and ability to obtain information from them and I didn't know if you had any further observations, given all the experience you had about whether we might enhance our dialogue in that respect.

DR. COHON: Again, I appreciate the question. First of all, just face time, more interaction with people who live there, more is definitely better. This may sound trivial, but it's turned out to be quite important for us.

The way you dress -- I'll never forget this, where I had my first meeting as Chairman, I forgot just which, I don't know if it was Parumph or Beatty, it was one of the small towns and we were welcomed by one of the local county commissioners who started out by saying this is the most suits we've had in this town since Jimmy died or something like that. And went on to say you don't look like us and we took that to heart. So when we have meetings now in these places, we dress in jeans and workshirts. We also instituted, we added to our meetings -- yeah, it was easy for me to --

CHAIRMAN MESERVE: I've got to see Ed cowboy boots and a cowboy hat.

(Laughter)

COMMISSIONER MERRIFIELD: Out of South Boston in cowboy boots? I'm not sure I can. Sorry.

DR. COHON: We also added opportunities for informal contact between Board Members and the public, so it's now become a standard feature of our meetings in Nevada to have, at the beginning of both days coffee and donuts and all the Board Members come and we have no agenda and anybody is welcome and it's a chance to just buttonhole a Board Member and talk.

These are various things you can do. They seem small, but they can have an impact. I have to point out though when we say the public, there's a really small group of people who come to all of our meetings and that leaves out the 99.99 percent of the people who don't come to our meetings and maybe a lot of them don't even -- maybe only vaguely know about the issue.

That will change, I think, over the next few months. We'll start seeing a lot more people we've not seen before because the issue has been more in the news, but it leaves open the bigger question of how do you reach out to the public, the broader public. I don't have an answer for you on that. That's just plain tough.

COMMISSIONER MERRIFIELD: As you think about that some more, any further suggestions in that regard are always welcome. I appreciate that very thoughtful response.

The Board has in reviewing DOE's material and this goes to the issue of C-22, obviously, there's some degree of predictability in the nature of hundreds of years regarding how some of these materials may work, but extrapolating that out to thousands of years without more information is quite difficult.

What is your confidence, the degree of the conservativeness of the predictions that DOE is using relative to C-22?

DR. SAGUES: My personal confidence, I can offer here my professional opinion and I"m talking here a little bit of modeler as well. A lot of my work in my research involve predicting the durability of civil structures like bridges and the like in the 100 years range.

We have a hard time doing that because we have a limited amount of information and we're trying to extrapolate many decades into the future. And that has a certain amount of confidence and it's limited and so the confidence that one has in extrapolating over an extremely long time is significantly less and the only way to increase that confidence, at least from my professional opinion, is to know more about the processes that make this tick, the kind of processes that are responsible for this material to last.

I have a transparency or an extra graphic material, if we could have that maybe shown because I wanted to give an idea of the -- a little bit of a model of a numeric idea of what we're talking about.

CHAIRMAN MESERVE: Do you have a numbered graphic?

MS. VIETTI-COOK: I saw them head back for the lights.

CHAIRMAN MESERVE: Very good.

DR. SAGUES: I just wanted to indicate a little bit more about the nature of what we're trying to do and I think that that's shown up there in that transparency. You should look at the vertical axis. That is the nominal service life that one expects for a system in this particular case, the repository and it is in years and at the bottom you have 10 years, a 100 years, 1,000, 10,000, 100,000, 1 million and so on.

So you just look at the horizontal area. Now, never mind that I don't have a line for right now, but what we have right down there in the gray area is the area in which you have direct, immediate engineering, ground truth kind of information. Passive materials, materials such as nickel alloys with chromium, maybe aluminum, 150 years or so, but we haven't experienced integrated experience direct, nuts and bolts kind of knowledge that extends to about 100 years. And that's all that we know, all that we can say that we really have in our hands from the point of view we tried it and it worked.

And well, if you want 10,000 years for sure, you want to be a little bit further ahead of that, maybe have another magnitude or so and what I indicated is a desire range is what we would really like to be. And you see there an extrapolation gap of 2 to 3 orders of magnitude. We have this little data of direct knowledge and we want to go 100 to 1,000 times farther ahead into that.

So if you ask me as an engineer what I think, if I have a direct experience with something for a 100 years and I want to extrapolate over 10,000 years, I want to say we have very little confidence on that.

Now if I know why the materials is lasting, then my confidence increases proportionally and of course, in the history of engineering and science, there are many times in which people design something with a new material and it worked. You work a very long time.

But to have confidence in that, you have to know a lot more about what makes that material withstand that aggressive environment. You know, the nickel, the chromium, and so on out of which these are made is -- those materials are quite reactive. If you put them in an oxidizing, relatively moist environment they will go.

What happens is they build this crust of oxide that almost completely seals the material from a certain environment. So what we have indicated to the DOE is that knowledge of the fundamental processes that make

that layers table is essential to go ahead and breach this immense extrapolation gap that we're trying to do.

So I don't know if I answered your question, but I tell you more or less where we stand personally, where some of us.

COMMISSIONER MERRIFIELD: It was a useful answer, but I guess the question still remains whether it's you, whether it's DOE or whether it's ourselves taking a look at this information, we're all dependent on the same facts and the facts are we don't have extrapolation out that far so we've got to base it on models, information we have available in making reasonably conservative assumptions. And the heart of my question is given those factors, is DOE making appropriately conservative assumptions in analyzing that material?

DR. SAGUES: Okay, again, talking from my personal perspective, I think that they're moving in the right direction. How much ahead in that direction they will be by the time in which an SR decision comes up and a licensing decisions comes up afterwards, that is going to be determined partly by what the DOE is doing at this time, partly by what will be the outcome of the present investigation, both experimental and more from the fundamental understanding, theoretical standpoint.

And at that time we as the Board, I think we're going to be looking at the evidence and we'll indicate, look this is more or less how we see that it operates and we'll forward that to the decision makers for them to decide if that is enough.

COMMISSIONER MERRIFIELD: I guess a related question goes to the issue of high temperature, the high temperature versus the low temperature model which you focused on.

One of the things that the Science and Engineering Report indicates is that with the high temperature modeling, you are more likely to have the packages stay out of contact with water because you're driving, the heat is driving it in a way. I don't quite square that. I know you've got some concerns about that high temperature model as it relates to corrosion, so I'm wondering if you could explain for me a little bit better that interaction relative to the water intrusion in a high temperature design versus low temperature design.

DR. SAGUES: Certainly, there are corrosion processes that you could imagine. Suppose you have an extreme situation, you have a repository design and then you have some rock fracture in some unexpected channels that will end up with a jet of hot water impinging on the package.

Everyone understands that that is an undesirable situation and I assume that someone could quantify some kind of a probability of that happening. Certainly, the probability or rather I feel that that probability will be greater at the heart of the repository because we are upsetting the system dramatically by doing that when you go to a lower temperature or maybe we'll know better how those thing will happen.

But let's talk about something a little bit more subtle. Let's talk about cases in which you have a relatively thin layer of very hot water, maybe a few molecules thick, maybe a little bit more on the surface of the material mixed with salts the way the deposit did.

Well, in that case you have the metal surface in contact with a hot brine and in those cases there is instance after instance in the technical experience that shows that you can run into some serious trouble with the performance of even very highly performing alloys. There are phenomena such as stress corrosion cracking that can happen under those conditions that require an extremely small amount of electrolyte.

You don't need anything to be dipped in water. It's enough with just the moisture at the end of a crack to propagate the problem. And those things increase with temperature and oftentimes they may increase exponentially with temperature. They are thermally activated processes oftentimes. That's where we are concerned.

Every few degrees that you go up in temperature, you may increase the rate of processes by two times, three times, who knows. That order of magnitude, that's why we are -- we keep this very close eye on temperature and that's why we would very much like to see hey, here is a lower temperature. We haven't investigated this and we found out that this is maybe 10 times better or 100 times better or maybe it's only two times better or maybe it's some process we don't know, it's worse actually, but we would like for the DOE to go through that exercise. We, as reviewers, would like to see that because it will facilitate our review task a lot more.

COMMISSIONER MERRIFIELD: Two final quick questions. First one relates to international counterparts and the Fins are quite well along in their efforts of trying to site a repository. The Swedes have spent a significant amount of time on their efforts as well and have been looking at a variety of different metals and I didn't know if the group as a whole had looked, had taken a look at some of those foreign efforts and whether there are any sites for us to gather from those.

DR. COHON: As a general matter, the Board does track and benchmark what's happening in other countries' programs and we stay in touch with counterparts where they exist in other countries. And some board members travel, from time to time to those countries to see first hand what's going on.

With regard to the metals, in particular, Alberto, do you want to --

DR. SAGUES: Yes, last year I personally had an opportunity of visiting representatives of both the Swedish and the Finnish programs. Their operating environments are completely different. In that case, we're talking about of course, copper canisters. They are located in mostly reducing environment as opposed to an oxidizing environment. The deterioration processes are altogether different, but having said that, needless to say the overall question is pretty much the same design for extremely long periods of time and we certainly study what they are doing, looking at the parallels and try to translate as many of the lessons that we learned to the review of this particular repository.

COMMISSIONER MERRIFIELD: Are they looking at both low and high temperature designs in the same regard?

DR. SAGUES: Their design is essentially much lower temperature design than the present base case design. So I guess in our parlance, that would be more of a low temperature design than high temperature design. Sometimes, foreign representatives visit us during our board meetings and so on

and at least on the part of the Swedish program one of their statements that I remember quite distinctly is keep the temperature low from the point of view of enhancing the likelihood that their design will be more successful and that was also the kind of message that we were getting concerning this repository.

MS. KNOPMAN: Sweden also has surface storage, centralized surface storage which they presume will continue. That's part of their operational program.

COMMISSIONER MERRIFIELD: Thank you, Mr. Chairman.

CHAIRMAN MESERVE: I'm sort of the new boy on the block on this. I know you've had the opportunity for interactions with my colleagues, a lot of these issues before.

On the uncertainty point, I must, let me pursue a little bit some of the questioning that Commissioner McGaffigan had started. It would seem to me and you can correct me if I'm wrong that there's a connection here of uncertainty and bounding analyses that ideally we all like to understand the repository at very high levels and reducing uncertainty is desirable.

But it would seem to me that even our function at the NRC at least which was to make sure if some confidence that a regulatory standard is met and it's terrific if it does better, but we need to have some assurance that regulatory standard is met that where there is uncertainty that abounding analysis would be a satisfactory way for DOE to respond and that the problem, I think that you've indicated is that there are some optimistic components of their performance assessment.

Am I understanding this correctly? One way that DOE could deal with this situation is just make sure they prune out the optimistic assessments, put a bounding analysis in, if they have uncertainty, and that that would solve the problem as well, or is there more fundamental issue with regard to uncertainty that we need to worry about?

DR. COHON: There's a more fundamental issue with regard to uncertainty that I'm not sure you have to worry about. In the Board's view, you note, we're careful to say my own view or the Board's view, this is a Board position.

We think that DOE should be striving to be able to make a statement to the Secretary or the President, a Member of Congress, of the following sort: after 15 years of studying Yucca Mountain, we have determined that Yucca Mountain will meet the EPA standard with a probability of X percent. Or, we'll meet the standard, but there's a probability of Y percent or 1-X percent that will not meet the standard. And it could be more complicated than that and probably should be or more involved than that.

That's quite a high hurdle to get over when you're analyzing such a complicated problem. It's different from saying with reasonable expectation Yucca Mountain will meet the standard and then having the iterative process that Commissioner McGaffigan described before that the Commission will undoubtedly engage in to understand just what you're dealing with here in terms of what that means, for what reasonable expectation means.

I think that those kinds of summary uncertainty statements are crucial for people to understand Yucca Mountain. That's sort of at the top level.

How do you produce such result from a TSPA when it's made up of such a large number of submodels and each of those submodels have so many assumptions and parameters as part of them necessarily.

Bounding analysis can get you to a certain point. I wish I could come up with a good example that would fly here, but I can't. If you had to do a bounding analysis on every parameter, I think that seems right, you'd have nothing to hold on to, right? I mean if you had -- suppose you felt very good about your models and your parameter estimates and you had probability distributions associated with each of those, except for climate change.

That was the only thing that you really were uncertain about, great uncertainty. Let's bound that. I can see very well how that would work, very neatly, to produce a nice neat result that you can say, Mr. Chairman, even under the worse conditions, this works. But if it's climate change and you're saturated zone model and couple processes and others, each of which you have to start with a bounding analysis, then I think that unravels as a way to capture uncertainty.

I think also that a bounding analysis gets you quite far in dealing with -- it gets you farther in dealing with the NRC's problem than it does with the Secretary's problem. Does that help?

CHAIRMAN MESERVE: That helps although it seems to me that there may be a little confusion in my mind that there could be a confusion here for some uncertainty and risk in that you may have some phenomena where you just have some frequency distribution. You know it very well and you can't get to a more deterministic sense about what's going to really happen. You end up with a frequency determination. That's not uncertainty. And when you say that you need to know with a certain probability that the standard will be dealt with, you have to deal with that problem whether you have some frequency distribution that may not be an uncertainty issue, however.

DR. COHON: I have more to say, but you go ahead.

MS. KNOPMAN: No, you keep going.

DR. COHON: Fair enough. The pros would say and I'm not a pro in this, the pros would say though what you just described, you're right, that's a very good distinction, the risk versus uncertainty and when you have a probability distribution for some phenomenon, for a parameter for a model, we would call that risk.

Uncertainty is the word they reserve for not even having a parameter distribution, probability distribution. We use the word uncertainty to embrace both of those and maybe we're being somewhat sloppy in that. We mean the uncertainty quote unquote, the fact that we need to use, they need to use probability distributions for parameters, the fact that they can't know in some instances what the right model is and then sort of the next step towards even closer to true uncertainty where we don't know and we can't know because we just don't have enough information or enough familiarity or theory for the phenomenon we're talking about.

MS. KNOPMAN: I'll just amplify something that Jerry said before. To me it gets something to the nature of the difference in I think a very important difference in a site recommendation decision and the nature of that decision and then the nature of a regulatory proceeding and decision.

And the Board not being a regulatory board or having any

regulatory authority has tended to look at this as not necessarily a risk minimalization problem, but a conveyance of degree of understanding to the public that that's in some ways the way we've interpreted the site recommendation decision. And again, we're not bound by any specific standard in the way we make those judgments of technical validity, but I think another way of saying what Jerry said was how well do we understand what's going on in this or might be going on at this site with this proposed design and there are limits to that bounding analysis to the point where maybe you don't understand what's going on at all. And that's where the -- it's not a clear breakpoint as to how far you can go working around your lack of knowledge or intrinsic natural variability or whatever to the point of saying we don't understand what's going on.

So in some ways it's not a technical answer to your question, but it's really a different kind of decision in kind that I think we're maybe facing here.

CHAIRMAN MESERVE: There may be some things that are uncertain, but you're comfortable on the basis of bounding analysis, it doesn't make any difference, extreme assumptions don't affect anything and I presume that we all could live with that uncertainty. It's where there is possible consequences on actually what the real performances and whether that's meaningful, you have issues.

MS. KNOPMAN: Right.

CHAIRMAN MESERVE: Let me ask a question about the corrosion point. When I first saw your slides I had the impression that we sort of had caught DOE in a Catch-22 that you need to show that corrosion performance over a long distance, a long time and it's obviously impossible to do that until you run the repository and add something else that you're going to. I now understand that your argument is that in order to have the comfort over long-term performance you need a fundamental understanding of the phenomena that enables us to extrapolate on a base that we have a scientific foundation for the extrapolation.

What worries me still is that I know that people have been worried about the physics and chemistry of surfaces for a very long time and it's a hard field and this really picks up on a point that Commissioner Merrified made. How much confidence can we have in the time that would exist before there has to be a demonstration to us, presumably that satisfaction by DOE that they can put together a license application of that decision that you can really make advances at fundamental levels that are going to illuminate these issues and take these issues off the table, if that's what's justified?

DR. SAGUES: Yes, that's a -- the time element, the time to do research kind of element. That's a difficult, that's a very difficult question. It may be a function of how much of a case agencies like yours would feel that this is an appropriate case to justify something.

I should say that the amount of knowledge that exists concerning the behavior of passive layers in the kind of environments that we are considering has been increasing consistently and is increasing right now, say about a generation ago there were questions as to whether a passive layer consisted of a layer of oxide on the surface of the metal and maybe it was just a monolayer, but absorbed oxygen atoms or molecular structures of such type.

Nowadays, we're able to do direct in situ underwater scanning totally microscopy imaging of the individual atoms in the oxide layers and knowing their crystal orientation and so on. So there's a lot more about what the -- a lot more known about what these things are and how they go together.

Indeed, the DOE right now has started its peer review group looking at some of the fundamental issues. We're doing a little bit of that on our own so I think that we are seeing in the last couple of years a burst of activity into trying to address this.

How that works out within the regulatory time frame and the like, that I cannot myself comment very much about.

Issues -- something that has been mentioned now and then is to take advantage of the confirmance of the performance confirmation period to buttress some of these holes that may need to be filled with knowledge for a much more reliable long term extrapolation.

CHAIRMAN MESERVE: In your comments initially in the slides on the high temperature design as opposed to a lower temperature design, the emphasis was on the capacity to be able to model a lower temperature design with greater confidence and that that's -- that was the thrust. In response to some of the questions, however, you left the impression with me that your feelings are stronger than that and that you believe that, in fact, a lower temperature design is not only easier to model but may well be much better.

DR. SAGUES: That part of it i don't think that we can say that. We feel that there is a chance that it may be better, but I don't think that that's, at this moment, we're in accord.

DR. COHON: It's a fair observation. I think the Chairman is right when we talk about this and your comments are typical of Board comments when we do discuss it, but what drives it really is this uncertainty associated with a couple of processes. That's really what led us in the first place to suggest to DOE that they look at a cooler design and compare it to a high temperature design, but you're quite right, there are other dimensions to it and it came up today.

CHAIRMAN MESERVE: What are DOE's views on this? How do they react to you when you --

DR. COHON: This is actually, if you'll allow me to expand a little, say a little more than you intended with that question, I've wanted to point this out. The Board is in a rather curious position. I don't know if there's been a Board ever like it before that is created by Congress, independent, no authority though.

We were created to look for problems, basically, and that's what we do. And that puts DOE in a curious position. I said in my remarks and I'll repeat now, they've really been very responsive and respectful of the Board and we think the program is better for it. But if I were in their position I think the same kind of dynamic would have occurred as we've observed, that is the Board observes something.

Over time, we get to understand it better by asking questions and getting feedback and eventually we recommend something. Well, in the meantime, of course, the many hundreds or thousands of people at DOE working on a particular aspect of this problem have gotten to a certain point and invested

a lot and now here comes this Board saying wait a minute, we don't know if that really works.

An organization of that size that invests itself in a particular idea doesn't turn on a dime and that's been the whole history of the relationship between the Board and the program for completely understandable purposes and we have many, many instances of this throughout the history of the program. And this is no exception.

So high temperature design, which is really very attractive, I mean elegant even, to a designer, is something that I think the program has been very invested and a lot of people have gone very far in and now here comes the Board saying wait a minute, why don't you look at this? Well, it was slow to embrace the idea and that's still going on.

I would add that there's a -- and we made this remark in passing, that there's a technical problem that DOE has in analyzing and comparing a colder repository to the base case higher temperature repository and that's because this whole thing turns on a couple of processes, but as we noted before TSPA is weak in its characterization of a couple of processes, so how do you really get a comparison if your primary tool for making the comparison is limited? That's a problem and DOE is trying to deal with that now.

DR. SAGUES: I would like to add something, if I may. There is another extreme and that is a scenario whereby we will get together with the DOE and we will start to design a repository with them and of course our function is not to do that, so the question of how much the technical ideas that we may voice in the process of reviewing the process, how much they can be engaged by and with the DOE is an issue that we have to be very careful about because then our function will be compromised.

CHAIRMAN MESERVE: We have somewhat the same problem as you can appreciate.

DR. SAGUES: Yes.

CHAIRMAN MESERVE: Good. I'd like to thank you very much. This has been extraordinarily helpful. We both have some challenges in front of us and hopefully we'll persevere.

Thank you very much and with that, we're adjourned.

(Whereupon, at 11:33 a.m., the meeting was concluded.