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NUCLEAR REGULATORY COMMISSION

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ADVISORY COMMITTEE ON NUCLEAR WASTE

139th MEETING

(ACNW)

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TUESDAY,

DECEMBER 17, 2002

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ROCKVILLE, MARYLAND

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The Advisory Committee on Nuclear Waste met at the Nuclear Regulatory Commission, Two White Flint North, Room T2B3, 11545 Rockville Pike, at 10:36 a.m., Dr. George Hornberger, Chairman, presiding.

COMMITTEE MEMBERS PRESENT:

DR. GEORGE W. HORNBERGER, Chairman

DR. RAYMOND G. WYMER, Vice Chairman

DR. B. JOHN GARRICK, Member

DR. MILTON N. LEVENSON, Member

DR. MICHAEL T. RYAN, Member

ACNW STAFF PRESENT:

JOHN T. LARKINS	Executive Director, ACRS/ACNW
SHER BADAHUR	Associate Director, ACRS/ACNW
HOWARD J. LARSON	Special Assistant, ACRS.ACNW
ANDREW CAMPBELL	ACNW Staff
RICHARD CODELL	ACNW Staff
NEIL COLEMAN	ACNW Staff
TIMOTHY KOBETZ	ACRS Staff
MICHAEL LEE	ACRS Staff
RICHARD K. MAJOR	ACNW Staff

C-O-N-T-E-N-T-S

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

(10:43 a.m.)

CHAIRMAN HORNBERGER: The meeting will come to order. This is the first day of the 139th meeting of the Advisory Committee on Nuclear Waste. My name is George Hornberger, Chairman of the ACNW.

The other members of the committee present are Raymond Wymer, who is the Vice Chairman, John Garrick, Milt Levenson, and Michael Ryan.

During today's meeting the committee will, one, meet with and discuss the staff's analyses for understanding repository performance. Two, prepare ACNW reports; and three, prepare for tomorrow's meeting with the Commission.

John Larkins is the Designated Federal Official for today's initial session. This meeting is being conducted in accordance with the provisions of the Federal Advisory Committee Act.

We have received no requests for time to make oral statements from members of the public regarding today's session. Should anyone wish to address the committee, please make your wishes known to one of the committee staff.

It is requested that speakers use one of the microphones, identify themselves, and speak with sufficient clarify and volume so that they can be readily heard.

Before proceeding, I would like to cover some brief items of interest. One, the NRC Chairman, Richard Meserve, announced on December 12th that he was leaving the agency at the end of March to take over as President of the non-profit Carnegie Institution of Washington.

He has been a member of Carnegie's Board of Trustees since 1992. His replacement has not yet been named. He took office in October of 1999, and will leave the agency 15 months before the expiration of his 5 year term.

He will be missed by all for his most capable and effective leadership, and that all certainly includes the ACNW, who holds Chairman Reserve in high regard.

Other items of interest. On December 6th, 2002, the ACRS, and that is our junior other committee, advisory committee, elected the following officers for 2003. We will correct the transcript.

(Laughter.)

CHAIRMAN HORNBERGER: Chairman Dr. Mario Bonaca, Vice Chairman Dr. Graham Wallis, and Member at Large Mr. Steven Rosen. Another item of interest is

Paul Boehnert, ACRS senior staff engineer, has announced his retirement on January 31st, 2003, from the NRC after some 30 years of service to the ACRS. His presence will be missed by all.

At today's meeting, we are going to have -- the item as I had announced was staff analyses for understanding repository performance, and John Garrick is the cognizant member, and I will turn the meeting over to John.

MEMBER GARRICK: Thanks, George. This committee has had a long interest in trying to understand the implications from the performance assessment of the performance of individual systems and the importance contributors to the performance major that will be in the final analysis the basis for licensing the repository.

The NRC has been conducting several studies to add to that insight, particularly with regard to the role of individual barriers and the transporting and mobilization of particular radionuclides.

So I think we are going to hear some more about that today, and I think that Tim McCartin is going to lead that discussion. tim.

MR. MCCARTIN: Thank you, Dr. Garrick.

Yes, and first of all I will say that you will notice a few of the slides look remarkably similar to what I presented in September.

I won't spend a lot of time on those, but as we mentioned in September at your meeting, we are in the process of trying to ensure that we have the necessary tools in place, and a strategy for what kinds of analyses we will do.

And as of September, we are giving you real time work that we are doing on the strategy. Also, in terms of some of the calculations, we are doing to see how valuable that strategy is.

In September, you wrote a short letter based on that meeting. I will say that today you will see some calculations where some of the suggestions that you made in that letter we actually have tried to implement in a very ordinary fashion.

And I think it is going to provide some significant insights. These will continue along those same lines, and I think there is a great example of a sort of just continuing dialogue, and whether it results in a letter or not, I obviously will leave it up to you.

I think once again that as we proceed down this path things are evolving quite a bit, and there is a work going on. I think it makes sense that we will stay in touch with the staff maybe at the next meeting, or two meetings hence.

It might make sense to provide some more information as it continues, and I will say one thing that I personally find a little disturbing, is that sometimes people are referring this as my strategy.

Please be aware that there are at least five potential strategies at the NRC, all involved in work. I have got the biggest mouth, and so they put me up here. But it really is a joint effort.

And all of the accolades and things that look good to that group here and at the center, and complaints, and I will take all the blame for the things that didn't look well, or didn't go well.

CHAIRMAN HORNBERGER: Tim, just a response to your initial comments here, and I would point out that in March that we are planning to have a workshop on TSPA and TPA, and so I think that there may be a natural follow-on to this kind of thing.

MR. MCCARTIN: Yes, definitely. With that, like you said, I will probably go through a few of the slides that are actually just a mere repeat of what we had in September, but it provides a little of the context for the entire strategy.

So I left them in a package for that reason, but I won't dwell on them. I will go through sort of a background of why we are doing this strategy, and the framework, and example calculation, and summarize things at the end.

When I put these out for comment by others, everyone told me that I had a typo in terms of the example in caps. That was intentional. It was not a typo. I just want to stress that these are preliminary calculations being done as an example.

We expect to improve upon them, but this is really being done in the context of are there elements of a strategy that seem to be working, and other elements may not until we have done some simple preliminary calculations.

And that's why example is in caps. We aren't trying to suggest that we have been as thorough as we have, say, in some of the TPA calculations, where we do a sensitivity analysis every couple of years.

And this is in a much smaller scale.

But it is quickly going to get into a much more systematic and comprehensive evaluation like this TPA calculation, and sensitivity analysis results that you have seen in previous meetings.

With that as the background, and as was said, the staff -- we are intending to conduct a number of analyses. We think it is a benefit to have a framework for doing these analyses for a lot of reasons.

One would be that we want to make sure if there are any holes in our strategy, and that, gee, we are not prepared to review the license application in this area. We want to make sure and shore up those holes.

It also -- I will have to say in terms of risk communication/risk prioritization, I will say that being in PA for the last 20 years, I will take the blame for this. We have not done a good job in being able to communicate risk and communicate how we are prioritizing things.

And I know that the committee for years has been pushing at us. We don't quite see how you are prioritizing work based on risk. And the information is there, but somehow we aren't squeezing out the results, the information that allows people to see where the risks are, and the prioritization of different aspects of the program relate to the risks, et cetera.

And I think that part of this framework is trying to get at how can we best explain the risks, display the information, and display the understanding, which then allows you to prioritize according to risk.

And hopefully -- and I think there is some information that we will be presenting that I think we can finally get to that path where there is a clearer explanation of that.

In terms of the analysis types, and I am on Slide 5, that we presented in September, the analysis types have not changed. We are looking at four broad categories of analyses.

One with respect to the overall repository system. Next, the capabilities of the engineer and natural barriers which I focused on primarily in September.

The effects of uncertainty in parameters, and the effects of potential limitations of the technical basis. And those four -- in September, I merely went over the capabilities of the engineer and natural barriers.

Today, I will go over all four, although I will be a little shorter on the barriers because of what I did in September. So going to the first calculational area, the overall performance of the repository.

In terms of the regulatory context, clearly there is the quantitative performance objectives for human intrusion, ground water protection, and individual dose.

Why are we doing those? Well, in our review of the DOE license application, this provides an independent assessment of the DOE performance assessment, and it also allows us to identify some of the risks, important parameters, models, assumptions. We are doing that through a sensitivity analysis.

We would put the sensitivity analyses we do with respect to the overall quantitative goals, limits, in this category of the overall system performance.

The next slide shows the analyses, and clearly we are looking at the calculation of the expected dose, and then also a calculation of the concentration and ground water, and doing sensitivity analyses.

So those are the simplest ones to understand, and obviously there is a quantitative limit. The next category of analyses is the capability of the barriers, natural and engineered.

The context for the regulation as we

discussed a little it in September was clearly the repository is to be compromised of both engineered and natural barriers.

The rule requires the Department to describe each of the barriers' capability, and I guess in terms of capability that a barrier is defined as something that -- and I include the definition here, that substantially reduces the flow of water or radionuclides, or the release rate from the waste.

And so the barrier -- some people have implied at times that a barrier could be anything, and I think the definition of a barrier ties in that. It does have to be something. It is not any travel time, or any delay would not be sufficient to be categorized as a barrier.

In terms of the rationale for the analyses, once again it provides an independent evaluation of DOE's description of a barrier's capabilities. It helps our interpretation of the performance assessment.

And I think this really is one of the biggest aspects of barrier capability. When I look at a performance assessment result, for example, and let's say an RPA, and I think that our dose at 10,000 years is .02 milligrams.

That is a low number. There is almost -- I have no basis for saying why should I believe that number. It is small, and below the limit. I think the capabilities of the barriers, a good description there, you can look at those capabilities, and then begin to understand whether that particular dose that is being estimated by the PA code, the code makes sense relative to the capabilities of the different barriers.

And in my example, I think you will see that I will go into a lot more detail when we get to that part of the slides. And certainly it allows to -- when you look at the capabilities of the barriers, you also identify what are the more significant barriers, and from the standpoint of Part 63, we are expecting the technical basis would be commensurate with the importance of the capabilities of particular barriers.

And barriers that do a lot, we would expect to see substantial technical basis supporting that barrier. In terms of the analyses that we might do, and here is where it is hard not standing up and pointing, but I guess I will have to a little bit here.

Here is where I would like to get into the presentation of September and the letter. You will see or I will point to the tracing or following of radionuclides through the system, and what the committee suggested.

We aren't as quick as the letter would indicate. Obviously the letter I think was sent out on December 6th. We were here when the committee wrote the letter and heard the discussion, and that particular aspect about tracing radionuclides through the system got us to thinking.

And you will see some calculations that we had done to try to in a rudimentary way implement that idea. I think that is very useful. In terms of the kinds of analyses we would do, you are looking at performance indicators with respect to a particular system or component, a subsystem or component.

That actually should be subsystem rather than system. And you are looking at hold up time for specific radionuclides, and you could have release rates and water contact.

Also, pinch points. The committee also has suggested that there might be particular parts of the calculation where you could go in and look at possibly the release of radionuclides at that particular point, be it be, let's say, at the bottom of the unsaturated zone, et cetera.

All those kinds of things are analyses that we would do all in the context of understanding what the barriers are doing, but also understanding the repository system.

Next is the uncertainty in parameters and models, and the regulations specifically requires the department to account for uncertainty and variability in parameters.

It also requires the Department of Energy to look at alternative models that are consistent with the data, uncertainty in the models. There is also with respect to FEPS, features, events, and processes, the DOE is required to look at and consider the FEPS effect in both the timing and the magnitude of the dose.

And that is important, and I think that everyone sort of focuses on the magnitude of the dose, but it also talks to the timing of the dose, and you will see that in some of the suggested analyses that we will do associated with that timing of the dose.

With a 10,000 year cut-off, it is important to consider uncertainty in estimating the timing near and around that 10,000 year compliance point. In terms of the rationale for our analyses, we certainly want to understand the effect of uncertainty on the results.

And also this isn't just with respect to the dose estimate. It also has to do with respect to the capabilities of the barriers. That is included in the uncertainty analysis.

We want to evaluate DOE's treatment of uncertainty, and it helps us review the license application. Also, as we have noted, often times conservatism is used as an approach to deal with uncertainty.

These calculations that we might do, we need to understand the uncertainty as it relates to DOE's use of conservatism. And certainly we want to understand where the important uncertainties are, one again, with respect to the technical bases.

It is hard to separate the technical bases from the uncertainty. In terms of the analyses one might do, you are familiar with certainly some of the uncertainty analyses that we presented in previous meetings for TPA exercises.

There is also looking at alternative conceptual models, and also going as we have presented to the committee, analyses beyond 10,000 years.

We are not trying to push the compliance period beyond there, but you want to be sensitive to uncertainties in estimating the arrival times of certain radionuclides, and how important are some of those assumptions, models, with respect to the timing of the dose, and that is an important aspect.

And finally the fourth area is potential limitations in the technical basis, and clearly the regulation requires DOE to provide a technical basis for the performance assessment, and we have even talked to the comparisons with detailed models, empirical observations, including natural analogs.

That is one aspect. The other aspect is in the regulation one of the reasons that there is a multiple barrier requirement is that it enhances the resiliency of the repository.

You aren't relying on strictly one barrier. You have multiple barriers. And part of looking at the limitations in the technical basis is that it is tied to that multiple barrier requirement.

As you will see the rationale for doing this is that it is a way for us to examine the resilience of the repository to unanticipated conditions or events.

We want to understand the degree of conservatism, and there is a certain safety margin if you will that is applied, and the fact that we have multiple barriers.

We want to examine the significance of potential misinterpretation of the current information, and that here is our -- it is getting at the limitations of the technical basis.

We have a technical basis and the Department will put forward a technical basis in our review, and what are some potential limitations there where we might be wrong.

This is really sort of the what if question, and certainly understand the relationship between barriers. There is a masking effect that I will also get into quantitatively in some of my slides later on.

But there is a problem with looking at the repository system in the context of the single dose value, because by the time that you get there, you may have 4 or 5 different barriers, and depending on the effectiveness of the different barriers, it is hard to understand the contribution for what effect the different barriers downstream are.

Clearly the waste package, my own personal opinion, it shows up the most important, because until it leaks, nothing gets out. It has to leak before you see anything, and so that first barrier always tends to -- has the potential to cloud the thinking of the other barriers.

And that masking effect is getting at trying to understand limitations actually in our analyses, depending on how it is done. And we are hoping to do -- you will see additional calculations that I think help give us a clearer view of what is going on.

The analyses that we might do in this context is certainly looking at performance beyond 10,000 years. The reason that I give an example of the waste package here, is if I do the current version of the TPA code, and if I run it, no waste packages fail in 10,000 years.

Well, that is an interesting result. It certainly is a value to run it longer, and to go beyond 10,000 years and see the nature of the failures, be they corrosion failures, and how it fails, and to what extent, et cetera.

And so in looking at the waste package, you want to go beyond.

MEMBER GARRICK: In the spirit of probablistic thinking, do you really mean to say that there is no failures here. That the probability is extremely small?

MR. MCCARTIN: Well, we certainly have the initial defectives, but I am saying that with the current TPA code, the estimate is that there are no failures in our code prior to 10,000 years.

CHAIRMAN HORNBERGER: How about if you did 2 billion realizations?

MR. MCCARTIN: I would say that we still would get with the current version no failures, but you are right. There could be additional chemistries that could be considered. Additional rock falls that could affect, and that if added in, and that is part of what in looking at the results that you have to look at, is what is included in the calculation and what is not included.

And I would agree that if you included more things that at a very low probability that you would get additional failures.

MEMBER GARRICK: Yes, because even in a probablistic analysis, there is a number of parameters that are assumed to be constant, and therefore, at the micro level, if you violated the strategy of a probablistic approach, but it is what has to be done in most cases to make the model realistic.

MR. MCCARTIN: Yes.

MEMBER GARRICK: Or to come up with a model that is manageable. But, for example, solubility. If you assume that solubility is constant, certainly that is going to be a different result probablistically speaking than if you assume the solubility has a probability distribution.

MR. MCCARTIN: Yes.

MEMBER GARRICK: And so if you are really rigorous and really systematic, the answer is that it is probablistic rather than yes or no, or zero or one.

MR. MCCARTIN: Yes, absolutely, and there is no question that the corrosion rate that we have in our code, and DOE has in theirs, is very related to temperatures in the range of chemistries that one assumes in the code.

And a lot of the work that we do for corrosion, we do off-line to see do we have the right mix of corrosion chemistries in our code, and which would absolutely change the potential for some corrosions.

And that is one of the actual upgrades that we are doing to our particular TPA code currently.

MEMBER GARRICK: Yes.

MR. MCCARTIN: In terms of evaluating

barrier effectiveness, we have seen DOE use, and we have done some of this also in the 5th and 95th percentile distributions to see how the effectiveness of the -- of what the barrier does relative to the uncertainty in some of the parameters for that, and the graded barrier analysis where you may in the spirit of a what if calculation, you might degrade the barrier somewhat to see its effect on performance.

And you can see that there is a range of different analyses we are suggesting. We are in the process of trying to estimate or get together with which ones of these do we want to start on now, and how to order them, prioritize them.

And you are going to see I think in each one of the bins different analyses that we are going to propose. We can't do them all at once, but we are digging a little deeper to see are these the right kinds of analyses, and are there other things that we should be doing.

And this is where, and obviously not necessarily today, but if the committee can look at the kinds of analyses, and the different bins, and provide suggestions, that would be helpful.

And we hope to provide quantitative analyses of all of these. All of this is being done in the context of reviewing DOE's TSPA. and I think what we also want to do is that we initially want to look at our results in our TSPA code. We just know it a little better than the DOE's.

However, that has to change or is going to change over the next few years. You are going to start to see, okay, here is what the information, and the understanding we have from our code, and how do we understand DOE's code.

There are differences, and there are similarities, and start to relate them to the DOE results. And I think that does line up very nicely with what Dr. Hornberger suggested, in terms of the March meeting.

And also today we are using primarily our own results, we are looking at the DOE results and h ow they relate, because it is really what DOE is relying on and what their technical basis is.

And with that, I will go to the numerical part of the presentation if you will, and I have to stand up for this still, although this is pretty low. And as a first cut, one of the problems that I had in a broad sense with risk informing, although I am a strong advocate for risk informing, one of the problems is that when we do our dose calculation, we see doses due to iodine and technetium almost exclusively.

And we aren't getting information about all of the other radionuclides, and in trying to get a sense of should I be concerned about that or not. And what I have attempted to do is try to put some perspective on the inventory in the repository, looking at a sweep of a few radionuclides.

I did this a little bit at the last meeting, how I upgraded it is. You can look at the percent of the curie amount for the repository, and I decided to calculate a percent of the hazard of the repository that each of those nuclides represents.

And I calculated the hazard by multiplying the inventory by the dose conversion factor. Not surprisingly --

VICE CHAIRMAN WYMER: How did you get your inventory? I mean, there is a whole spectrum of spent fuels in there with various --

MR. MCCARTIN: It has been published. I mean, it's not -- I am jut using the published amounts for spent fuel that have been around for quite a while.

VICE CHAIRMAN WYMER: And that is pretty complicated to do it accurately, and maybe that is good enough.

MR. MCCARTIN: Well, you might see some small changes. I don't think in terms of when you are looking at, let's say, 63,000 metric tons, you are pretty close in the ball park.

VICE CHAIRMAN WYMER: A lot of different burn-ups and so on, but okay.

MR. MCCARTIN: Yes. Not surprisingly, the Americium 241, which is the largest inventory, actually has a fairly high dose conversion factor, and represents 56 percent of the hazard, and plutonium 240, 25 percent.

Interestingly, iodine and technetium combined represent less than one-thousandth of one percent of the hazard of the inventory in the repository, which I didn't think was going to be quite this low.

But it is something to keep in mind, that when we are looking at the iodine and technetium doses, we are looking at a very -- for the repository, a minuscule amount of the hazard.

The question is what are we doing about the large portion of the hazard. We are not seeing doses from that, and I think that is an important aspect. I mean, these are five radionuclides.

I get it for nine altogether, and plutonium 239 is 18 percent, and I decided to include selenium and nickel just to test what will I learn by including sort of a range of radionuclides from the inventory.

And you can see that it is a very, very small amount of the hazard, but the question is, and as someone on the committee suggested, let's trace some radionuclides, and I want to trace both the ones that are causing the dose, and the ones that have the highest hazard, and maybe some other radionuclides just to see what does it tell me.

And with that as a perspective on the inventory, in tracing the radionuclides through the system, I wanted to try to get a number that was comparable between the different -- between different points.

And so I came up with a way to calculate years for each of these. Clearly at the top, waste package lifetime is relatively simply and needs no explanation.

In terms of solubility limit, I elected to pass a hundred liters per year through a waste package and see how long would it take to reach out to the inventory in a waste package based on a hundred liters per year, and that it was all available to go in the solution.

And how do they get a hundred liters per year you might ask. I took a depeculation rate of 10 millimeters per year, a cross-section of the waste package of 10 meters, and if all that peculation went straight down through the waste package, that is a hundred liters per year.

And once again, just to get an idea of different ways or different points in the system to calculate a delay time, and see what it is telling you for a release rate.

The fuel isn't released instantaneously, and for this I just assumed a 10 to the minus 3 per year release rate, which would be the fuel that is completely released in a thousand years.

Then using some of the calculations for that, some of which I had in September, in terms of transport time in the Calico Hills non-welded, vitric unit, which -- and the reason for a non-welded vitric unit, it is a very high conductivity porous unit, and so the flow is primarily porous, and not fracture flow.

And then for the saturated zone, the transport time in the saturated fractured rock would be primarily fractures and matrix diffusion, and transport time in the saturated alluvium.

In using these calculations, first in terms of the number, the radionuclides that we see primarily in the dose calculations, and I included path life, and hazard index as I called it for these different radionuclides.

This is somewhat what I presented in September, and you can see that the release rates was assumed to be a thousand years, and the waste package lifetime on average, the TPA code does estimate approximately a 50,000 year lifetime.

You can see for solubility limits that iodine and technetium obviously are very soluble. But for neptunium, it takes 8,000 years at a hundred liters per year, which is a fairly high flow rate through the waste package.

If it was less than that, this would increase, and you can see the travel times through the unsaturated zone and the saturated zone add up to approximately about a thousand -- once again, iodine and technetium are unretarded.

Neptunium is retarded in the porous unsaturated zone for that particular unit. I will point out that is one important difference between our calculation and DOE's at present.

We have approximately -- this unit being below, about 50 percent of the footprint, and DOE has this unit throughout below the footprint. And then the saturated zone in the alluvium of 20,000.

However, when one goes to the next set of radionuclides, three radionuclides that in terms of hazard make up around -- I should be able to do that but I didn't, but I think it is around 97 percent of the hazard, and it is a fairly high percentage of the hazard.

Once again you have 50,000 years for the waste package lifetime, and in terms of solubilities, you can see for these three radionuclides that if they are limited by solubility, you are getting on the order of a hundred-thousand years upwards of a few million years to release the contents of a single waste package at a hundred meters per year.

The release rate, once again, is assuming a 10 to the minus 3, and so it is a thousand years. And in the porous unsaturated zone, over a hundred-thousand years.

And in the alluvium, over a hundred-thousand years; and 5,000 years less for the plutonium. Part of what this will allow us to do though is you can see that interestingly enough, or not surprisingly, we never see any of those radionuclides.

We can't run the code long enough to see anything for these radionuclides. And so when you -- and this is a part of the risk informing, that yes, iodine and technetium are producing a dose, but the flip side of that is that I look at these three radionuclides that account for a tremendous amount of the hazard of the high level waste inventory are completely screened out of the analyses.

Why? Well, there is a number of reasons why. I mean, you can see halfway here, in 430 years, a very long waste package is gone. However, the solubility limits is gone also before much can get out.

You have got other -- be it the unsaturated zone, or the saturated zone, you have tremendous delay times there, and that it is never going to get out.

MEMBER GARRICK: Tim, if you were to become more rigorous with respect to a couple of processes, would you think that would have any effect on this, on these numbers?

MR. MCCARTIN: Coupled in what sense?

MEMBER GARRICK: Well, in the mobilization process given all the chemistry that is going on, and it is not as if it is a single radionuclide with a specific solubility seeing just water. It is seeing a lot of other things as well.

MR. MCCARTIN: Oh, sure. Well, to be continued, I guess.

MEMBER GARRICK: Okay. I was just curious if you had done anything to maybe account for that, or --

MR. MCCARTIN: Well, that is the point of this slide in terms of risk-informing and risk-prioritization. I think part of the previous slide you saw for iodine technetium, really pretty much the release rate, and how we are handling the release rate, is the primary way we could affect what eventually gets to people.

That with no retardation, it moves rather quick, and it is a small spiking release, because there isn't a lot of inventory, but that is the one area to look there.

When I look at these radionuclides, I think there is a story here that in the calculations there is capabilities in many different spots that significantly delay americium. Now the thing is that we need to go in and look at it, and say, boy, that is a tremendous delay, and what is the uncertainty.

What other kinds of things could affect this, and I am not a geochemist, and so I am not going to say that. But I think from a PA perspective, we would like to go back and challenge, okay, this would appear to be a lot of capability. What are the things that could affect it.

Likewise for these. Also, I think from risk-informed barriers, I look at this, and it isn't just that this hazard is 56 percent, but I have got a waste package solubility.

I have got a number of places where I have potential to affect that release significantly. And I think it is worth looking -- we need to consider the uncertainties, and like you say possible coupling effects, et cetera, because the chemistry could be very important there.

And it is a way to try to prioritize. Maybe there is very little uncertainty here, and a lot more here, and there is going to be trade-offs. And I don't right now, as a first step, first, it is displaying what kind of behavior are we seeing. How is the repository working, and where --

MEMBER GARRICK: Where this is very

valuable, among other places, is that it draws a clear distinction between hazard and risk, you know, and that is something that is often very confusing to the public.

And I think if you adopt the hazard definition of the dictionary that says that it is a source of danger, then that is a very different concept than risk, and I think this explains it very well, and portrays that very well.

VICE CHAIRMAN WYMER: Tim, two of the principal contributors to dose are technetium and neptunium. Is that not right?

MR. MCCARTIN: And iodine.

VICE CHAIRMAN WYMER: And iodine.

MR. MCCARTIN: Well, you know, neptunium --

MEMBER GARRICK: It depends on the kind, and for a very, very long time, it was pretty much neptunium.

VICE CHAIRMAN WYMER: Now, all three of those elements are very subject to adopting different valance rates. If there were mechanisms available for changing the valance of these, that have you considered at all the effect of that in some of these calculations, and that they may be a different species than you are assuming?

MEMBER GARRICK: That is what I was getting at with a couple of processes.

MR. MCCARTIN: To date, no. But I think it is something -- and I don't know if these are the right categories, the solubility and release, but it is a way to try to understand in my mind where are you getting some performance.

VICE CHAIRMAN WYMER: I understand that, yes, but it's just that there are other things that I personally think should be considered.

MEMBER RYAN: Tim, there is another couple of lines that you could add on the bottom. For example, you could take it through the alluvium, and if you then think about withdrawal scenarios and then the actual calculation of dose, I would suggest that there are two more lines.

There is a lot of variability. Well, let me just say it this way. That the withdrawal and exposure scenarios are very stylized. So there is I think a lot of fruitful thought that can go into whether are those conservative and by how much.

I think that, for example, the withdrawal of water then becomes the only source of water for everything, including growing food, recreation, and everything else. So that is something to consider there.

The last one that is very often ignored the dose conversion factors. We are all using FRC 19 or ICRP 30, or something, and those dose conversion factors are intentionally conservative for the purpose of protecting workers.

Those are not environmental dose conversion factors that take into account environmental chemistry and other processes. So years ago, I took a look, for example, at plutonium.

And the GI tract uptake fraction, which is critical to actually calculating a dose, was somewhere up in the 90th something percentile of the range of F-1 values that were out there in the literature.

And so the inherent nature dose conversion factors are very conservative. And I am going to offer that only to say why don't you add those two lines and see what that gives us.

And another thing, for example, with iodine being on top of the list, particularly iodine 129,

I have never really seen a satisfactory treatment of iodine 129 dilution in the iodine pool.

If you have Iodine 129 and it is competing in the iodine pool, you will find out that you will load the thyroid very quickly before you can have a limiting dose from I-129.

Because if there is normal iodine going in, and all those Loci are taken up, you can't have it. So there is some other -- and maybe that is the next level down.

But I think there are some other things that would be very helpful once, you know, Iodine is at the top. Okay. Well, let's pour in the details. So there is just some other areas on the actual exposure scenario and dose calculation part that I would proffer as being good extensions of this analysis.

And I applaud, and it is very systematic and clear how things get ranked pretty quickly. So it is real helpful.

MEMBER LEVENSON: I think, Tim, on the solubility issue that somewhere along the line you really need to define what species you are using for your base case, because if you are using the most, very most soluble form, then you don't have to worry about all of the chemistry that might occur, because they all will be reducing the solubility.

So you need to have some feel for whether your base case solubility is most soluble, least soluble, little, or a lot.

MR. MCCARTIN: Right. It is a fairly important issue. And I think for all of these, although I have reduced things to a single number, which is always dangerous, there are many things that I think -- and consistent with your December 6th letter that can we point to each of these and what the evidence is, and what the uncertainties are, et cetera, to give a sense of -- to put that number in context.

And I would like to think that ultimately we could look at our agreements and prioritize according to how the system is behaving. Likewise, something that I didn't talk about.

I mean, these are very low solubilities,and certainly the Department of Energy has colloids for plutonium that certainly defeat this long time. So I don't want to imply that -- and that's why I used the example in capital letters.

I was encouraged that in terms of trying to understand the system, and get a grasp of the system, where should I be looking. Should I be looking over there or over there. This is a way to start to begin to understand where I should be looking.

But clearly there is a lot of work in each of these to understand better what this number actually represents, the uncertainties and technical information supporting it. Did you have something, Andy, you wanted to say?

MR. CAMPBELL: Yes. This is Andy Campbell from the NRC staff. I just wanted to add to the issue of a couple of processes. A lot of these radionuclides, the information that Tim is drawing from, involves both experimental data, as well as geochemical calculations that the Department has done over the years, and that the NRC and the Center have done over the years.

And to the extent that that work has addressed this issue of how chemistry changes as it transports through the various layers and systems, there may a need for more work on couple processes, but this is kind of a first order look at that to see where you focus those efforts, because that can be quite involved.

MEMBER GARRICK: So what you are saying is that it is sort of partially embedded in the database?

MR. CAMPBELL: That's correct.

MEMBER GARRICK: The effect of couple

processes?

MR. CAMPBELL: That's correct,yes.

CHAIRMAN HORNBERGER: Andy, are you saying that this is not all based on congruent dissolution?

MR. CAMPBELL: Well, a lot of what Tim is showing you from the various units have to do with retardation factors.

CHAIRMAN HORNBERGER: Well, I know that, but I am talking about solubility.

MR. CAMPBELL: Well, it depends. I mean, technetium and iodine, the solubility is assumed to be one. It is assumed to dissolve.

CHAIRMAN HORNBERGER: I thought that you were hinting somehow the experiments have been done to incorporate at least to a certain extent couple processes. I always thought that we were assuming congruent dissolution of the fuel. I mean, has anyone done anything in congruent dissolution?

MR. CAMPBELL: That I don't know right off the top of my head, but that is a source tern issue as opposed to some of the KD values that Tim is incorporating for each of these different units.

MR. MCCARTIN: Yes, for this calculation, I am merely using the solubility limits, and assuming that it already is available.

Going to the last three nuclides, you can see once again not surprisingly uranium has a very low solubility and so there is some significant delays there.

The reason that I was -- and I can tell you that I picked selenium and nickel just by chance. I don't know what made me, and maybe something drew me to them. I don't know.

But oddly enough, when I did the calculations with the TPA code, I said I must have done something wrong, because if I look at the saturated zone I can see that I have a delay time in the saturated fractured rock that is greater than the delay time in the alluvium.

And I said that there is no way. It just can't be. The alluvium always -- I mean, it is porous flow, and when I looked further actually it was correct. Whether our parameters are justified, that is a different issue.

But the reason that this occurred is for the alluvium, we are sampling the retardation factor, and it samples over a fairly broad range. And I will say for alluvium that the retardation factor is sampled between 1 and 8,000.

So you can see that because of the one

that we are going to see that when this was done over -- it was a probablistic calculation and we tend to -- and I am using the average result, we are pushed to the lower end there.

For the fractured rock, we have matrix diffusion. And however the retardation factor for the matrix is not sampled, and we are using a value of approximately 2,000.

And here you can see that we were sampling between 1 and 8,000 and a value of 2,000, well, the fact that it wasn't sampled, we are getting a greater delay in that part of the system.

Once again, for me I am not disturbed by that. I think the reason that you are doing these kinds of calculations is to understand your system. Now, it certainly is worth going back and looking at, gee, we are sampling the KD here in the alluvium, and we tend to pick a single value that tends to be on the higher end here.

What is our basis for that, and that is the whole reason for learning what is going on and why. I mean, we may end up revising that, but I think that is the reason that I would not have guessed that was occurring.

Selenium and nickel are some of those

nuclides that we don't really look at because they are never causing a dose, but I think for all of the calculations that we want to have a technical basis for why you are doing something.

You want to be consistent, and you want to be able to explain all of the results. And conversely when I look at, say, neptunium, we have a similar kind of flip flop of this.

The reason for that is for neptunium that single value tends to be on the low end, and maybe we did that -- it was done because we want to be conservative for neptunium, because it could be a large dose contributor.

Here we didn't look as closely at what was done there because it never shows up, but I think it points to ways to double-check your logic, your thinking, what you are putting into the code.

And ultimately I point back to what we need to do is to have a good understanding of what is going on with our results, and then we can start to move to the risk prioritization, risk informing things based upon a knowledge of what we are doing.

MEMBER RYAN: Tim, I guess that to me that that last part, where you are comparing those 3,600 versus the 2,000 kind, that sort of says that even if there are variations or changes like the ones that you have described, it doesn't move selenium or nickel out of the low hazard index group, or as dose contributors.

I mean, I think that is real helpful to help confirm that nothing is moving from one of low risk up to an intermediate or even a higher risk. So I think that is real helpful from that standpoint.

I guess it doesn't suggest to me that you would want to somehow further study that or investigate it. It is just a confirmatory sort of activity?

MR. MCCARTIN: Yes. That's a very good point, because yes, if you look at the hazard index, these are very low hazard things. It is not to say, oh, boy, we really need to understand this. It is getting -- what is our rationale here in understanding that.

MEMBER RYAN: Great.

MR. MCCARTIN: And I think that is an important part of keeping the hazards in mind there. You want to -- the risk informed process is one of that you want to spend the effort on the things that can make -- relative to their contribution to risk.

MEMBER RYAN: And again the hazard index

is really the dose conversion factor. So I would suggest to you that those aren't fixed points either. Those are also subject to - and in some cases - fairly substantial potential variations based on the GI tract uptake fractions and other parameters in the modeling for dose.

MR. MCCARTIN: Yes.

MEMBER RYAN: Some radionuclides, for example, are based on plutonium chemistry, and many of the other actinides are not based on any particular understanding of curium metabolism.

But it is assumed to be like plutonium. So there are things like that which I think have the potential to maybe make some shifts in the hazard index, but that is a variable that I would put not in the header, but down on the line to think about.

MR. MCCARTIN: Yes. And it is still dose conversion factor times inventory, because that is the part that I think is very important, because if I just had dose conversion factors, there would not be such a spread in hazard.

But the fact that i.e., technetium or a small portion of the inventory -- selenium and nickel -- are also a relatively small portion of the inventory. And I guess as we move forward trying to prioritize and look at the agreements that we have, do we have the right agreements in place.

I think they are, and once again I think here is where the committee could help us out. There is a lot of information here, and as I said, clearly there is stuff behind all of these numbers that need to be understood.

But between the hazard index, and what is going on at different points of the system, and how many of the different points are providing how much delay, there is a lot to consider in terms of what we should be doing.

MEMBER LEVENSON: Tim, from the standpoint of a couple of processes, I am having a little trouble with the idea of assuming the solubilities. When you look at the uranium number, it is going to be a long, long time before any of that stuff is really available for dissolution.

It doesn't come flowing out of the middle of the crystals and matrix of the material, and the largest group from many of the things that you have got there, the very largest delay in retention is likely to not be in the UZ or the SZ, or anywhere else, but just even with water dripping through the dam containment, the stuff is locked up inside the uranium.

And until the uranium dissolves, it is not available for solubility.

MR. MCCARTIN: Yes. Now, I will say though that the calculations to date, the release rates in the DOE code, and in ours, too, are relatively fast. Now, there may be that there is some uncertainties there that we are not considering, but --

MEMBER LEVENSON: But what are they in the physical world, and not what are they in the model.

MR. MCCARTIN: Right. Well, both the values for the solubilities, and some of the release rate is based on experimental information, and some measurements. It is limited -- and I know that Dick Codell, who has worked a lot on source term issues, may be able to add something.

MEMBER LEVENSON: It is not so much the solubility as the release rate.

MR. MCCARTIN: The release rates tend to be fairly and surprisingly higher than are estimated in the model, and vary temperature dependent, but Dick, do you have something there?

MR. CODELL: Yes, I would like to clarify. This is Dick Codell. Both our model and DOE's model

-- and we are using the same data, of course, show the release rates quite a bit higher than just the solubility release of uranium.

The rates for most things are more tied to the rate that the uranium degrades, and this isn't dissolutionment. It is oxidation of the uranium, UO2 to higher oxides, and other higher valance states.

So there are some instances that are important, like neptunium being tied back up into secondary uranium minerals like schoepite, and then may be retained and released at a lower rate as the schoepite dissolves.

But the rates are very much higher than you would expect just from dissolution of the uranium.

CHAIRMAN HORNBERGER: But, Dick, I guess another question is are these then based -- and I assume they are, on empirical observations done in hot cells dissolving fuel?

MR. CODELL: Yes, indeed. There is quite a bit of that going on or went on at Batelle, Northwest, and also at Argonne.

VICE CHAIRMAN WYMER: Is that based on fairly long term dissolution or is it short term? Is it a question of whether it is sufficial release, or whether it is --

MR. CODELL: Well, it is both. If you are looking at release rates for things like iodine, there are fast release pads from the iodine and the cesium being so volatile that they migrate to the surface or to the gap between cladding and the fuel, and they can be released. A small fraction of that can be released rather quickly.

And we take that into account in our PA model, but there are long term experiments that go on for a period of a few years, and at grains or small fragments of the actual spent fuel.

VICE CHAIRMAN WYMER: Well, if we are dealing with discussing the inventory of these things in the fuel, then you really have to be talking about fairly complete dissolving of the entire uranium body.

MR. CODELL: No, it will take a very long time to dissolve it all, but it is really tied to the surface area of the fuel which is large, because it is all fractured up, and there is a lot of area.

VICE CHAIRMAN WYMER: I don't see that that makes any difference.

MR. CODELL: Yes, it does. If the diffusion rate of water and the diffusion of the dissolved species in and out of the uranium are tied to the area of the fuel, because the rates for diffusion through the cracks are much faster than -- well, they are not limiting.

So there is a lot of area where you get faster release.

VICE CHAIRMAN WYMER: Well, for the two that you discussed, I can understand it. Like the cesium and iodine, because they do tend to move on to the fuel rod, but some of these others, they are inside --

MR. CODELL: Right, but the fuel particles don't take that long to dissolve, and the ones deep inside the fuel rods don't take that much longer than the ones close to the surface of the fuel rods.

VICE CHAIRMAN WYMER: So is the solubility number in a sense, wrong? It doesn't include everything it should.

MR. CODELL: Well, that is just talking about uranium there.

VICE CHAIRMAN WYMER: Yes, and so am I.

MR. CODELL: Well, I think uranium takes a long time, and it would take a long time to dissolve.

MEMBER LEVENSON: For those things that aren't mobile and are inside the uranium -- for those things that are not mobile, and inside the uranium grade, it is hard to see how they can be seven orders of magnitude faster than the dissolution of the grain.

MR. CODELL: Well, like I said, they are not being released at the rate that the uranium dissolves. They are being released at the rate that the uranium is degrading or oxidizing. It is experimental data. I am not making this up.

MEMBER LEVENSON: Well, the question always is that with experimental data it is always what was the measurement and how relevant is it to this issue.

MR. LEFZIG: If I could make a point. This is Brett Lefzig from the NRC staff. I think this is an example where analog information tells us that Dick has said he has not made up, and isn't really made up.

For instance, Pina Blanca, which we now knows still has close to 80 tons of uranium, there is a radium 226 deficiency of 50 percent. And radium has a half-life of 1,600 years, which is saying that the system is open enough that you can lose 50 percent of the radium all the time.

Yet, the uranium stays behind. What it says is that the uranium may not dissolve and reprecipitate very rapidly. So that the entire inventory of Radium 226, which should be in equilibrium if it is a closed system, isn't.

So it is entirely consistent with this. You have a fast release rate, but the solubility is limited, and therefore it reprecipitates, and it can't be transported out of the system.

MEMBER GARRICK: I think that these are interesting geochemical and chemistry discussions, but the point is that if you have some assumed solubility that is 7 orders of magnitude greater than it might be if there is a grain sequestering kind of phenomenon, and it doesn't contribute to dose, all the arguments that I have heard you put forth would make it less soluble.

And if solubility is one, and it still doesn't contribute, then we just cross it off the list and we are done? I think it is important to separate these important technical point discussions from the overall goal of why they are used here. And this is to rank and to identify things that are of importance in influencing decision making, rather than to answer the science questions.

MEMBER LEVENSON: We are not limited to these three, with the generic one, including those things that do contribute to the dose.

MR. MCCARTIN: I think it is important to consider everything that is behind these numbers. Like I said, when I do these calculations, assuming that everything is available, and when you go back and look at this in more depth, maybe there is some other arguments, some uncertainties, and things that will make these things higher, lower, and that is the next step.

But the issue was where do we begin, and the biggest problem or I think the biggest hurdle that we had was that there was an unhealthy preoccupation with iodine and technetium, and while they certainly are the first ones to get out, it is not the only issue that we need to understand with respect to the repository. There are other nuclides that have significant hazard.

And we want -- and those are being completely screened out, and it may be absolutely justified, but that is part of our review, is to look at what is the basis of why we are never seeing these other nuclides, and this is a way to at least try to at a broad level look at what is going on.

But as we look at these deeper, will these numbers change? I would be surprised if they didn't, and as we bring in uncertainties, and the technical basis, but it is a way to start that process of prioritizing and being able to point back to something and how it would affect or have the potential to affect the risk.

And that I think is the strength of this, starting with some common understanding among the staff -- here is what I believe, and we see with our PA code.

Now, let's poke a little harder and look at the uncertainties, and look at the technical basis, and do we believe these numbers. And that in part I would submit is part of our DOE license application, we would want to understand different points like this, and do we believe what is there.

And then when you can fill out, be it a table like this or some other kind of approach or understanding, you can then see - do I have confidence that the dose requirement is met, do I have confidence that there are multiple barriers.

MEMBER GARRICK: Tim, I would like to clarify my comments. I will make it very clear that I am not criticizing at all what has been done. I think this is a very good approach, and I would like to see it continued, and I think the questions are just to help identify what sort of additional thinking ought to be looked at.

MR. MCCARTIN: Yes, I took it as a helpful comment and not criticism. I have a very thick hide.

MEMBER GARRICK: I think we better let you proceed. We have other commitments.

MR. MCCARTIN: Well, actually, that was my last one. I have a summary slide, and it is all the same one in September. There is just a lot of words here, and let me paraphrase that we really are in evolving the calculations that we do, and I am not sure that we can review the DOE license application in the areas that really make the most difference.

But as you can see, I think there is a lot of things to weigh. Risk inform is not just an iodine and technetium dose. It goes far deeper than that. And I think we are beginning to, as the analogy is often used, peal away the onion and to get a better appreciation of what is going on where, and why, as we continue to work with some of these calculations. Obviously there are terms, conceptual models, uncertainties that all need to be considered.

And we would like to come back and continue to discuss the results, and just as important, how they are being presented. I would say, what we are trying to do? And the bottom line is to present an understanding of the system in an unbiased fashion. How is this thing working, and that is just the simplest answer, and I think that is what this strategy is trying to get at to make sure we are ready to review the license application.

MEMBER GARRICK: And I think the idea of having these other radionuclides, particularly with respect to questions of coupling processes and interactions, chemical interactions, and valance changes and so forth is extremely important. In fact, there is one radionuclide that I still consider a kind of mystery one, that I'm not sure received enough attention, and that is protactinium, as to what really happens there.

There was a nit question that I wanted to ask you. Back on slide 8 you have a definition of a barrier, and you say a barrier defined is material structure or feature that substantially reduces flow of water radionuclides are release rate. I am sure that it doesn't - a barrier isn't just defined in terms of the release rate. Otherwise, the waste package would not be a barrier at least internal --

MR. MCCARTIN: No, it delays the release for perhaps years. That's actually pretty close to the paraphrasing from 63.

MEMBER GARRICK: That's what I'm getting at. And certainly the drip shield is a barrier, but if it is defined in the context of only being a barrier with respect to release, then it wouldn't be a barrier. But that is not what it means. You see, this definition sends our release rate from the waste.

It says barrier defined as material, structure, or feature that substantially reduces flow or release rate, you could say flow from the waste, or release rate from the waste. It is just a technicality.

CHAIRMAN HORNBERGER: Well, I mean, the whole thing says reduces flow of water or radionuclides, or release rate.

MR. MCCARTIN: While it is intact.

MEMBER GARRICK: But what is throwing me off is the ambiguity of "from the waste." You know, as opposed to to the waste, as opposed to --

CHAIRMAN HORNBERGER: isn't that the first part, reduces flow of water?

MEMBER GARRICK: Right, but you could say reduces flow of water from the waste. I know that it is a nit. I started out by saying that.

CHAIRMAN HORNBERGER: Oh, you think that the "from the waste" goes with everything?

MEMBER GARRICK: Right. Right. And it is a suggestion that the drip shield is not a barrier, and it certainly is.

MR. MCCARTIN: Yes.

MEMBER GARRICK: Okay.

MR. MCCARTIN: That was not intended. It wasn't all from the waste, no.

MEMBER GARRICK: Yes, I think that these analyses are really what is needed to begin to put a perspective on the issues, and even though -- and it also opens up the whole science issue associated with the analysis, and we have lots of questions about that.

It doesn't mean that as far as trying to better understand how the material gets to people, then we are really very interested in how you are approaching it. Any other -- Milt, do you have some questions? If not, George?

MEMBER GARRICK: Tim, on your four analysis types, when you said that you were going to touch on them all in your presentation, and I can certainly see how you touched on the first three, and perhaps I am being just particularly obtuse this morning, but could you give me at least a quick indication of how you have touched on the effect of potential limitations and the technical basis.

MR. MCCARTIN: Well, not in the calculations. I mean, this was a -- I wasn't trying to imply that I did all four of the areas.

CHAIRMAN HORNBERGER: I'm sorry, but I misunderstood that.

VICE CHAIRMAN WYMER: I think your questions were hitting around that fourth one quite a bit.

MR. MCCARTIN: But we didn't really do anything that -- other than the fact that I will say that in terms of the resilience of the repository for some of the -- well, where you see that you get delay time in multiple areas. That would certainly point to the resilience in that, and for that americium 241, it is zero whether I have a waste package or not.

That is pretty resident for the largest single contributor to hazard in the repository. So, I mean, in that sense. But I apologize. I wasn't trying to hit on all of the four areas.

CHAIRMAN HORNBERGER: No, that's fine. I just misunderstood. and you have clarified. But I want to -- well, on slide 14, I had another confusion when you talked about the -- and again this is under the potential limitations in the technical basis.

And then in the next bullet, you talk about comparisons with outputs of detailed process models, and/or empirical observations. Now, here is my -- the problem that I have had for a long time, and if I were a performance assessment person, I believe that I would be using as I developed my performance assessment model comparisons with outputs of detailed process models, and I would be using empirical observations, such as Dick Codell just indicated with solubility, as I built my performance assessment.

So my question is -- and I have not understood, for example, when people have talked about, well, we have to use multiple lines of evidence. Why aren't the multiple lines of evidence already in your PA? So, could you enlighten me?

MR. MCCARTIN: Well, I think they already are. And I guess I wasn't trying to imply that this was not in the PA, but in terms of when I look at the technical basis, DOE needs to provide a technical basis, and you right, that as they build their PA, there should be I would think -- and in many cases there are, multiple lines of evidence supporting why they chose a particular model, parameter, assumptions, et cetera.

This was just getting at as they do that what are the limitations in that technical basis. It is just the context for looking at the -- in terms of why are we probing into the limitations in the technical basis.

It is required and we want to understand this particular aspect of the technical basis, and part of it is its relationship to the -- how important is it to performance assessment that where are the assumptions, parameters, models.

Where is there significant uncertainty here relative to the importance to the performance.

CHAIRMAN HORNBERGER: Again, Raymond just suggested to me that, yes the technical basis is in, but it may be lousy. Is that --

MR. MCCARTIN: Well, that is what this is trying to look at. I mean, the --

MEMBER LEVENSON: Well, you may have also lost it in an abstraction.

CHAIRMAN HORNBERGER: Okay. I mean, I grant you that an analyst could make a mistake, and if you are talking about trying to find blunders in the construction of a performance assessment model, I understand it.

But again I suppose -- well, how are you going to determine from an analysis of the PA code whether the technical basis is lousy or not?

MR. MCCARTIN: Well, it is not -- it is looking at the -- in this sense, the limitation of the technical basis is that whatever it is that DOE provides the technical basis for a particular model.

Using the performance assessment to understand, well, what if we are a little bit wrong, what if the degraded analysis in the 5th and 95th percentile, does it make a big difference? And certainly our review in our critique of that technical basis should be relative to how much it matters if we are wrong, and that is what I was trying to get at with this.

CHAIRMAN HORNBERGER: So it is not independent of your third analysis type, which is effect of uncertainty in paraments and models?

MR. MCCARTIN: Correct, but this is getting a little bit beyond, and our uncertainty is -- and this is a subtlety that I couldn't make clearer. The uncertainty analysis is looking at more the range of the uncertainties that I have included in my representation of the repository.

This is more at the what if, and what if -- say I look at -- and I am not as smart as I thought I was. And for whatever reason, the corrosion rates are different, and the solubility ones are different, and it is looking in the context of -- the uncertainty stuff is that I know my uncertainties, and then I step over here and what many would call the epistemic uncertainty.

Now, I am not as smart as I really think I am, and I have misread the information, how worried should I be for some of these things, and this is trying to look at that I think qualitatively, you would look at how much evidence do I have for this piece, and that is where you go to the graded barrier.

And if I am wrong -- I mean, the easiest would be what if a small percentage of waste packages failed and the dose rose dramatically. Well, the fact that I am assuming I have a calculation that is assuming very few, if any.

And you might look at that technical basis with even more scrutiny to make sure that you aren't wrong.

CHAIRMAN HORNBERGER: All right. I understand that. The words on your slide just confused me. But just for the record, I wanted to note that I heard Michael Ryan say that the discussion of geochemistry is very interesting, and so I want to keep that in mind for the future. And with that, Mike.

MEMBER RYAN: I would concur that this analysis is very helpful and instructive, and so keep going. But I think I would extend it to not only the natural system and the failure mode surrounding packages and wastes, and so on, but I would push it out to that last step of the dose calculation, because we always say what is the impact on dose.

I think we need to examine the extraction and exposure scenarios, and dose conversion factors with the same kind of eye, because I think some of those I think we take as a hard fact, and in fact there is in the main conservatism, but certainly variability, if those were dose conversion factors originally and almost exclusively designed for workers in the work place.

So the tendency was to assume soluble forms, and assume conditions of exposure that would make those conservative. So I think a precedence in that arena would be a good addition.

MEMBER GARRICK: Yes, I have to add to that, too. I think this is really helpful in developing a physical feel for what is happening. I don't know where it is going, but let me tell you where I would like to see it go, because just based on experience, in the late '70s and in the '80s, we started presenting the risk results of reactors in a form that embedded the whole issue of sensitivity into the uncertainty.

And one way of doing that was if your performance measure is something like dose or something like in the case of a reactor core melt, and you do a risk assessment, and you end up with a probability function of the core melt, and the frequency of core melt, then the way that you can really manifest what is driving that core damage frequency are the dose in the case of a repository.

And there is a similar probability density function of the contributors put on that same draft. And so now you have a very impressive graphic of not only the uncertainty, but a physical picture of the sensitivity, if you wish, of the bottom line to that contributor.

So I can imagine a series of PDFs that would be on the same graphic as a PDF representing the risk of, say, meeting the 15 milligram per year dose standard. Those are the kind of graphics that really begin to decompose the issue of reactor risk into its fundamental components and where it was coming from.

How much of it was coming from the

containment system, and how much of it was coming from the high pressure injection system. How much of it was coming from the diesel generators and what would it look like if we added another one.

This is my opinion was a major breakthrough in our understanding of the importance and the relative contribution to performance of specific systems. So it would really be nice if we could eventually get to that point in this kind of work, but I think it is this type of digging that is going to be required for us to have some chance of doing that.

So keep up the good work. Any other comments from the staff? Yes, Mike.

MR. LEE: Just one, and it is just a kid of clarification, and if we could go back to slide 20 on page 10. I guess my comment is kind of a follow-on to what Drs. Garrick and Hornberger were talking about, in terms of digging into the technical basis.

Just going back to the Calico Hills non-welded vitric, and you pointed out that both the NRC and DOE rely on different assumptions regarding the geologic occurrence.

MR. MCCARTIN: Yes.

MR. LEE: Now, is this an area that -- I

mean, as an example, presumably we are all looking at the same data, but we are coming to different conclusions.

MR. MCCARTIN: It is one that we are looking at why, yes. It is one that we are looking at.

MR. LEE: The only reason that I point to it is --

MR. MCCARTIN: it is a big factor, and the geologists are looking at the information that we have used to estimate what the stratigraphy is below Yucca Mountain, and DOE has a slightly different approach, yes.

MR. LEE: So going back to your presentation, and throughout your presentation, that this is an example of an area where we might look at why we come up with differences in results, and try to reconcile the basis for the differences, and understand where the truth might actually lie?

MR. MCCARTIN: Right. Yes. And be aware that part of it is there are some areas where the Calico Hills non-welded vitric tends to pinch out or get very thin in some areas.

From an efficiency standpoint for the code, if you get a very thin layer, it becomes very difficult and time consuming to calculate it, and to transport through a very thin layer.

Because of iodine and technetium, and this is sort of where we sort of get caught, are unretarded, and they are the ones that eventually get out. A very thin layer does very little for iodine and technetium, regardless of whether it is matrix.

As you see, whether it is cracked or a matrix or just for CPU purposes, we in some areas have elected not to simulate very thin layers. But for certain nuclides that are post-10,000 year, it actually does provide even -- even thin layers can provide quite a bit when the retardation is higher.

And witness neptunium versus iodine. Now, neptunium isn't that retarded, but it clearly makes a big difference. So I will say that we don't necessarily disagree, or there might not be as much disagreement as I indicated, and that DOE may have very thin layers, and we just elected not to include that very thin layer.

MR. LEE: I guess more globally if I understand what you are saying, is that there is a desire certainly by the time we get the license application in that there is an understanding for the basis for the differences that is in each one of these squares to the extent that differences exist?

MR. MCCARTIN: Certainly, although I would put it in a slightly different way, and that is that I would say in the last six months to a year we are spending more and more time look in at DOE's TSPA and less time looking at our TPA.

We will continue to work and improve it,but our goal is to -- and I think I said it once before this committee, and it still is my goal, and it may be a foolish one, but we want to understand DOE's TSPA better than they do. And that is the goal.

And so in comparison to my help, yes, but the goal is that we are trying to move more and more towards this is what DOE has, and here is their technical basis, and here is how it is represented, and do we believe that DOE is saying or not.

And if comparisons are helpful, yes, but the emphasis is really more that we need to understand the TSPA. And as the committee knows, we have goals set in-house, and we are using it, and we are looking at it, and that really is the desire, is to understand how they are representing Yucca Mountain and the technical basis for it.

MEMBER GARRICK: Okay. Any other questions?

DR. LARKINS: Just a quick question,a nd I know that it is getting late.

MEMBER GARRICK: I hope it's quick, yes.

DR. LARKINS: Very quick. On page 15, view graph 15, you said that part of the rationale for the analysis is understanding the degree of conservatism, or safety margin.

Obviously you are going to have to roll the uncertainties and other things into your analysis in order to get an idea of the degree of conservatisms or safety margins, particularly when you start comparing with DOE's codes.

MR. MCCARTIN: Yes.

DR. LARKINS: Basically the question boils down to understanding the degree of conservatism that you are really going to need to go back and roll your uncertainties into your analysis, and you can't use point values and things like that.

MR. MCCARTIN: Absolutely. Oh, absolutely yes. I mean, it is easy to represent it as a single number, but it doesn't tell the whole story, although some of those -- the single numbers that I presented, many of them are the result of a Monte Carlo analysis in taking the average results, but you are right.

And that's why I stress that behind each of those numbers is a wealth of information, in terms of what the uncertainty variability means in the context of the behavior.

MEMBER GARRICK: Okay. If there are no further questions, I will turn it back to the Chairman.

CHAIRMAN HORNBERGER: Thank you. We are momentarily going to break for lunch. My look at the agenda for this afternoon suggests that we do not need to be on the record; is that correct? So we won't need the reporter after lunch.

We will reconvene at 1:30, when we will have a discussion of ACNW reports. We are now adjourned.

(Whereupon, the meeting was concluded at 12:13 p.m.)