UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION
***
MEETING WITH ADVISORY COMMITTEE
ON NUCLEAR WASTE (ACNW)
***
PUBLIC MEETING
***

Nuclear Regulatory Commission
Commission Hearing Room
11555 Rockville Pike
Rockville, Maryland

Tuesday, May 20, 1997

The Commission met in open session, pursuant to notice, at 2:00 p.m., the Honorable SHIRLEY A. JACKSON, Chairman of the Commission, presiding.

COMMISSIONERS PRESENT:

SHIRLEY A. JACKSON, Chairman of the Commission
KENNETH C. ROGERS, Member of the Commission
GRETA J. DICUS, Member of the Commission
EDWARD McGAFFIGAN, JR., Member of the Commission

STAFF AND PRESENTERS SEATED AT THE COMMISSION TABLE:

ANNETTE VIETTI-COOK, Assistant Secretary
KAREN D. CYR, General Counsel
PAUL POMEROY, Chairman, ACNW
B. JOHN GARRICK, Vice Chairman, ACNW
GEORGE HORNBERGER, ACNW
WILLIAM HINZE, ACNW
JOHN LARKINS, Executive Director, ACNW

P R O C E E D I N G S

[2:00 p.m.]

CHAIRMAN JACKSON: Good afternoon.

Today, we are meeting with the Advisory Committee on Nuclear Waste to be briefed on several technical issues related to management and disposal of radioactive waste. The Commission looks to the ACNW, as it is called, to provide it was sound technical advice to assure the safe management and disposal of this country's radioactive waste.

Today's briefing will discuss several completed projects and discuss various issues in the status of two other works in progress.

In looking over the agenda for today's meeting, it appears that we have a fairly large number of topics to cover so, if my fellow commissioners don't have anything further to add, I will turn it over to you, Dr. Pomeroy, and we will try to restrain ourselves until we finish each part. I can't totally guarantee that with this crowd, but we will try that at any rate.

DR. POMEROY: Thank you, Madam Chairman. We do have contingency plans, in case there are --

[Laughter.]

DR. POMEROY: Madam Chairman, members of the Commission, it is a pleasure to be here, as always.

It has been essentially one year since our last

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public discussion and, as you have noted, Madam Chairman, we have several items of interest that we wish to present. Our presentations will utilize, as a framework, the current ACNW priorities and, if we can have the first slide, please, those are listed. This is Slide Number 3 in the material that you have.

I would like to briefly run through what our priority issues are and indicate where we are going to give presentations within those.

Regulatory framework, there will be a presentation by Dr. Garrick on the Reference Biosphere and the Critical Group and if there is time I will talk some about agreement states issues at the end.

Waste containment and isolation strategy, essentially we are following that particular issue very closely and when our timeliness criteria is satisfied we will move ahead with that. But we are currently waiting for DOE's document.

Viability assessment and site characterization, Dr. Hinze will address igneous activity. That is a work in progress. We are currently in the process of writing a letter. And Dr. Hornberger will address flow and radionuclide transport under the site characterization activity and he will discuss coupled processes under repository design.

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Low-level waste, radioactive waste disposal. As noted, you know our views on that subject. We are not going to discuss those here.

I will talk briefly about decommissioning and expert judgment, perhaps, with time. Dr. Garrick will address the question of risk-informed and performance-based regulation. This is another item that is in progress; it will be in progress through the summer of this year. Uranium mill tailings fall under our timeliness criteria and they are not yet a timely issue for us.

The interim surface storage facilities for spent fuel, our initial review begins this month.

Moving right along, I would like to turn the meeting over to Dr. Garrick and he will address risk-informed performance-based regulation.

DR. GARRICK: Thanks, Paul.

As you know, most of our letters in one way or another make reference to risk-informed performance-based regulation and our letters certainly support that approach. While we haven't written a letter explicitly on this subject, given the frequent reference to it we thought it would be a good idea to discuss it some and to share with you some of our thinking on this subject and to address a couple of specific questions which I will get to in a minute.

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As far as risk-informed performance-based regulation is concerned and its use in the nuclear waste field, there are a number of factors that certainly favor that. Compliance demonstration is already rooted in meeting performance requirements. The EPA standards or regulations have a risk-based quality to them.

The regulatory standard, at least for high-level waste, is in fact probabilistic.

Regulations covering high-level waste are evolving with the anticipated first license application for a high-level waste repository, thus the timing seems to be good for us to do something constructive and useful here.

The PRA policy statement and the PRA implementation plan sets the framework for staff uses of PA and PRA.

As far as factors to overcome to implement RIPB regulation in the nuclear waste field, you have heard a lot about these. You have heard a lot about the comparisons between PA and PRA and so I am not going to repeat that because those presentations were very excellent in that regard. I am going to give a little bit of an ACNW spin on them, however, and maybe touch on a couple of items that were not covered before.

So as far as some of the obstacles are concerned, number one, risk assessment experience of NRC is principally

in the nuclear power field. The facility differences between nuclear power plants and repositories are extensive and thus there is a compromising of the relevancy of the experience base.

Engineered systems involving active equipment and hardware have been the principal target for the development of the analytical methods of risk assessment, although the level two, that is the containment and core response work, has many aspects to it that are similar to the performance assessment modeling challenges.

PRA started as a risk-based discipline, PA did not. Probabilistic features have been evolving in PA.

So one way to get to this question is to pick up on some of the things you have already heard a little bit about, as I said, and give it our spin. So let's pose the question: How can PRA approaches, methodologies and techniques be brought to bear on Pas?

Well, as far as the basic issue is concerned of what is the risk, we have to, through PA or PRA, answer the same fundamental three questions. What can go wrong, how likely is it and what are the consequences. So the basics are the same.

Now, while I promise not to get too much into the comparisons, I want to repeat some that you have heard about and comment on them a little bit.

As to similarities, both PRA and PA are scenario based. Now, I am speaking here more from the point of view of a practitioner in PRA in many respects than I am an expert on PA, which I am not. I am also speaking principally from the point of view of practitioner on the industry side when it comes to PRA and on the industry side, there is a considerable amount of emphasis on the risk assessments being scenario based.

The scenarios of both require definitions of initial states and end states. In order to have a scenario, you have to have a beginning and you have to have an end. Both have ultimate risk measures that involve health effects from radiation and both involve the philosophy of defense in depth.

Now, as far as the dissimilarities of PAs and PRAs are concerned, in general they are very dissimilar with respect to the roles of active and passive systems. The PA being principally an analysis of a system where the subsystems are passive. The nuclear power and the PRA being

born in an environment where most of the systems are active, although there are examples of passive systems.

There is the issue of accidents versus performance. The emphasis in nuclear plant risk assessment work is the analysis of rare and high-consequence accidents. In fact, that was the motivation for risk assessment.

. 9

Versus the repository emphasis on long-term performance.

There are considerable differences with respect to the time cycles, the time constants, the time constraints involved. Generally, the time constants associated with high consequence accidents in nuclear power plants is short compared to the time constants associated with the degradation of a repository.

There is the issue of safety goals for the case of nuclear power plants and no safety goals for the case of repositories.

There is the issue of unconditional risk versus conditional risk. By that, I mean the reactor risk assessments are, for the most part, unconditional in that they are not -- the risk calculations are not under the assumption of any particular initiating condition.

There is the issue of degradation rates versus failure rates. While the repositories have a slow change in their integrity, most of the accidents associated with nuclear power plants involve changes that happen over short periods of time, although there are the issues of aging and the issues, again, of some of the passive systems where there is a gradual degradation.

Now, what can we get from PRA that will help us in doing performance assessments? And I like to call them PPAs, probabilistic performance assessments.

. 10

Well, one of the things that we do in PRA that is very helpful from a model transparency standpoint is segment the problem into logical modules. In the old days, we used to call the modules the plant model, the containment model and the site model. The output from the plant model was a series of damage states that became the input to the containment model, the output of which was a series of release dates that became the input to the site model. So these were very logical pinch points that would allow us to analyze each of these segments independent of the other once we determined what these end states were.

The repository problem model lends itself to some of this same sort of thing. I will come back to that in a minute.

Data processing in the form of the results. In the PRA arena, there has been a great deal more dependence on Bayesian type methods for processing data and accounting for the effect of new information and taking into account the update of information as it becomes available. And the data processing was, for the most part, based on information quality with some of it based on modeling quality. But one of the things about the repository modeling that I have observed is that they are giving more attention to modeling uncertainties than at a similar time was given in the case of the nuclear PRAs.

. 11

The adoption of multiple risk measures. In the case of particularly the early PRAs of nuclear power plants, a full-scope, level three risk assessment involved maybe as many as nine measures of risk. I sort of like to draw an analogy between a skyscraper and a risk assessment that you

learn something by looking in one of the windows of a skyscraper but not much. You learn something about the risk of a nuclear power plant by looking at the core damage frequency but not much. It is much more informative to have multiple measures of risk and each time you learn something in addition.

The PRA experience in the nuclear plants that has been extremely beneficial and I think is a concept that has been reasonably well picked up in the repository is this business of importance ranking. You can rank scenarios, you can rank the initiating conditions and you can rank by other things that contribute to the risk.

So what I would like to do, and I have to apologize for this diagram, it is a little complex, but it helps me drive home this point of where we might look for enhancements in the repository risk assessments on the basis of our experience in the risk assessment of other facilities.

What this attempts to do is to modularize the performance assessment into particular segments, much like

. 12

the three segments that the nuclear plant is modularized. As a matter of fact, you might even draw an analog between the infiltration model here and the plant model and the combination of the engineered barrier model and the geosphere model as the containment model and then, of course, the biosphere model as an analog with the atmospheric dispersion or site model.

The modeling concept that was extremely helpful in enhancing the understanding of what was going on was when you did this, defining your output states from each of these modules in such a way that they indeed became the input states for the succeeding part of the model. So the infiltration model would have output states that would be defined on the basis of physical and chemical properties. You may have one state define on the basis of a certain temperature pressure and a certain chemical makeup of the water flow and so on. And this is where there is a major difference between PRA and PA in that when you do this, of course, the actual scenarios that you end up with are developed as a result of this process rather than doing it as it is often done in the case of a repository where you actually establish the scenarios in advance from end to end.

So this is an interesting thought that we are going to examine in a working group in a couple of months as to whether or not there would be any merit in structuring

. 13

the scenarios in this slightly different manner.

One other thing that I wanted to point out here is the question is if I wanted to -- if I wanted to see a repository analysis in a form that I would classify as risk informed and performance based, what kind of measures would I look for? My last exhibit there is just an attempt to delineate some of those.

One of those measures would be the dose profile, the dose rate profile, for example, the upper left-hand corner. Dose rate curve as a function of time, such that I have the entire profile available to me, as well as the uncertainty associated with it.

Now, this is a little different kind of presentation than normally one thinks of in a risk assessment because here we are talking about dose rate, we are not talking about the frequency of occurrence of an

event or what have you. But I like to kind of observe that what I really mean by a risk assessment is not deterministic versus a probabilistic but rather a deterministic plus probabilistic that what you really -- what you really get out of a risk assessment is another dimension. You get an expression of the confidence that the analyst has in their results. The issue of parameters or models, parameters of the models, that is another matter.

The second curve in the upper right-hand corner is

. 14

typical of what you might get as a source term curve as a function of time. Of course, you may want to look at discrete points in time in terms of how the uncertainty grows with time in a little more detail than would be given by that curve and that is the idea of the third set of probability density functions.

Then the fourth curve here, if I were giving this as a homework assignment and wanted to really see what was going on, I would ask for a risk curve on each of the disruptive events because they do assume a frequency character to them and therefore I can use the full arsenal of all of the PRA software to help me calculate a cumulative probability density distribution, complementary cumulative density distribution for each of the disruptive events.

Now, if we choose and desire to combine these into a single parameter for measuring risk, that's fine. But I think one of the things we have learned in the risk assessment business where it has matured some is that it sometimes gives you very important insights to not convolute and combine everything but to let it kind of speak for itself.

So this is just a few thoughts on where we are and what we have been thinking about.

CHAIRMAN JACKSON: Thank you.

Commissioner Rogers?

. 15

COMMISSIONER ROGERS: Where do you see it going from here?

DR. GARRICK: That's a good question.

Well, I have been in this business a long time. I have seen it go quite a way but I have never seen it go anywhere without a fight; that is to say, a tremendous challenge.

I think that I have seen an enormous amount of progress in the IPA work just in the last two years in embracing the notions of probability into the models so I think it is moving in that direction and I think there is a lot of shaking out yet to do and some of the things we are talking about here are candidates for how it might shake out.

CHAIRMAN JACKSON: Commissioner Dicus?

COMMISSIONER DICUS: No questions.

CHAIRMAN JACKSON: Commissioner McGaffigan?

COMMISSIONER McGAFFIGAN: No questions.

CHAIRMAN JACKSON: You are off the hook easy.

DR. GARRICK: That is much easier than I had expected.

[Laughter.]

DR. POMEROY: If not, then I would like to keep Dr. Garrick talking, if I may. In Tab B.2 of your book, we have a presentation on the reference biosphere and the

. 16

critical group.

Dr. Garrick will carry that on.

DR. GARRICK: Well, this is an issue on which we did write a letter. The way we have sort of approached it, and this is also an issue where, of all the issues this committee has addressed, I don't know that I can remember one where there was greater involvement by all members of the committee than on this one. So I am not on the spot here; the whole committee is on the spot and I expect them to speak up.

But we approached this from the point of view of what are the real questions here and the questions that we see are, first off, what's the issue and is there an overarching one and what is the essence of our advice and what is the basis for that advice.

Now, the question, as we see it, is basically the exposure scenario that should form the basis for demonstrating compliance at the proposed Yucca Mountain high-level waste repository. This is a subject that has gotten a tremendous amount of attention. It was the central issue with respect to the National Academy of Sciences committee that looked at the technical basis for the high-level waste repository standard.

Embedded in this issue, as it was so clearly manifested in that report, are the definitions of the

reference biosphere, the critical group and the previously defined time of compliance. Now, we supplied you with a letter on time of compliance so we are not going to say much about that today.

As far as our advice on this issue is concerned, it took the form of first trying to be generic in terms of some definitions for the reference biosphere and the critical group and to attempt as best we could to address the whole issue as much on a scientific basis as we could but recognizing that there were gaps in our scientific knowledge and that those gaps would most likely have to be dependent upon the establishment of policy.

We also gave a lot of attention and emphasis to the importance of the staff taking advantage of known site characteristics and repository design features to provide increased focus on the questions, to provide every opportunity possible to reduce the uncertainties. This was an opportunity to do that. Seldom do you get in the position of creating a regulatory framework for a single facility. Then, finally, we offered some suggestions with respect to some basic principles for calculating and interpreting risk measures.

Now, as to the essence of our advice, we kind of came to the conclusion that what we meant by the reference biosphere was the environment in which the biota and the

critical group comes in contact with radionuclides. As far as the critical group is concerned, we indicated that that is the population group that forms the basis for calculating the radiation risk to the public and including but is not limited to the person or the individual at greatest risk.

As far as the policy requirement is concerned, the area where there was clearly some scientific gaps was the basis for defining demographics and behavior of populations that are at risk from the repository over the time period of compliance.

Site specificity, again, we urged the use of known site and design characteristics to generate regulations and guidance that will reduce technical uncertainties and

increase confidence in the assessment of the safety and overall performance. Now, we talked about risk assessment principles, made reference to the issue of consistency of application of risk-based methods and what we meant by that was primarily that if you are, for example, examining a scenario it is wise, we think, if you are taking a risk-based approach to do that throughout the entire scenario rather than applying it in some modules and not in other modules. But it is something that we put quite a bit of emphasis on.

Now, the basis for our advice and the theme of our letter was that the whole issue of the reference biosphere,

the critical group, should be as much scientifically based as it possibly can be and we should push that to the limit. Whatever we come up with as science is developed that reduces the dependence on policy, we should be able to take advantage of that science.

So policies only where there are scientific gaps. We also, as we have in most of our advisory letters of late, emphasized the need for the adoption of a risk-informed and performance-based approach and, as I said, we also pushed the notion of consistency of application.

CHAIRMAN JACKSON: How easy do you think it would be to come to real unanimous or near unanimous agreement on what items would constitute scientific gaps?

DR. GARRICK: Well, I think that there is fairly good agreement as to where we are lacking sufficient scientific information to put forth what we would call a scientific basis and I think we have identified that. I think that one of the things I have been encouraged by in the repository work as I have gotten more involved in it is that the well designed research program, well orchestrated analysis program can provide a lot more information than I suspect many of us thought would be possible.

So the only area that I think we are uncomfortable with, with respect to a scientific gap, is the area having to do with the demographics of the future and the human

behavior in the future.

DR. HINZE: Not to be flippant, but it is going to be a lot easier to determine what the gaps are than to arrive at a policy. I think that is clear as one looks at the problem.

DR. POMEROY: And I think there is another aspect that I would like to emphasize and that is that the policy decision is going to be very, very serious in certain of these areas. The location of the critical group, which may be specified by the EPA, may be specified by the NRC or it may be specified in some ways and offered to you at the staff level.

That choice alone can determine the acceptability or nonacceptability of a given repository in a generic sense and we have examples of that that we could discuss.

DR. GARRICK: I think there is another point that is important, since there has been a lot of discussion about uncertainty. If one adopts the notion of the science of uncertainty, that is to say accepts the fact that if some parameters are going to involve considerable uncertainty, as long as you represent that uncertainty in your modeling and, as some of us like to call it, tell the truth, it is possible to stretch the scientific basis considerably beyond what you might otherwise think is possible.

One of the things I think we have an illusion

about is that when we are working with a point estimate that we are working with truth or that we are working with complete knowledge. Seldom in the kind of work that I have been involved with, at least, has that luxury really existed.

So I think that we are not in as bad a shape there as we might and if there was any kind of information that developed that would allow us to represent even future demographics in terms of some parameters, albeit they would have large uncertainty bands, that would, at least, even there be a step toward bringing science into that process and we should certainly, in whatever regulations we evolve, accommodate that possibility.

CHAIRMAN JACKSON: Commissioner Rogers?

COMMISSIONER ROGERS: No, I think the questions so far were what I had.

CHAIRMAN JACKSON: Commissioner Dicus?

COMMISSIONER DICUS: Let me try to clarify something to be sure I understand it and this is on the scientific gaps and clearly you identified at least one area where policy requirement might come in on the demographics and the behavior of populations. And I wasn't clear as to whether or not that is the only place you have identified or you have identified others already or you think there will be other gaps.

DR. GARRICK: Well, there are others that are often talked about as bordering on scientific gaps. One of those activities that we have already mentioned is the issue of disruptive events and the role of disruptive events.

Clearly, there is considerable uncertainty in the frequency and severity, that is to say the hazard curve, associated with the large earthquakes, large magnitude earthquakes. Similarly, you could say the same thing with respect to igneous events and you could say the same thing with respect to other things that --

DR. HINZE: Human intrusion.

DR. GARRICK: Yes, human intrusion, meteorites, whatever. So those are all candidates for scientific gaps. On the other hand, I think that we have made a considerable progress in how to at least include them in our modeling. It is like the whole arena of the risk business. We first learn how to model active systems and then we started working on so-called external threats, such as earthquakes and storms. But we know how to do this active system modeling better than we know how to do external events, better than we know how to do human response, better than we know how to do organizational performance and so on.

So it is a gradual encroachment on these things that all contribute to the risk in bringing them into the technical arena and making them less subjective and more a

part of the analysis based on some sort of evidence. And if your modeling activity accommodates the treatment of parameters that have high uncertainty in them, there are quite a few things that you can do that you otherwise couldn't.

DR. HORNBERGER: Could I interject something to disagree just a little bit with John, which I'm fond of doing?

DR. GARRICK: They all are.

[Laughter.]

DR. HORNBERGER: Scientific gaps doesn't quite capture what we have in mind because scientists, as a scientist, we are fond of talking about gaps in science where we need more research dollars to close the gaps and I don't think that is primarily what we are talking about.

Earthquake frequency, there is some chance that science will get us better and better answers in the future. I don't think that we are going to get better and better answers from science on human intrusion scenarios. And they are the kind of things that I believe that we, the ACNW, was focusing on where policy was really needed.

DR. HINZE: If I might interject, one of the problems there is the location of the critical group. That is something where we can have some scientific input but, yet, it is going to be a policy decision. There is

scientific information regarding the depth of the water table, for example, and how the water table may vary with climate and thus the economics of the critical group. But this really fades into the policy area.

As much as possible, our message is use science as much as possible and then your best judgment in terms of policy from there on.

CHAIRMAN JACKSON: Commissioner McGaffigan?

COMMISSIONER McGAFFIGAN: Could I ask on the question of policy issues, both bills currently pending before the Congress try to settle at least some of these issues, assuming that is in their view the best way to settle it. Have you looked at the bills and seen whether -- human intrusion, for example, is dealt with in both bills -- and reached any conclusions as to whether they are dealing with these policy issues, these scientific gaps as the term was previously used?

DR. GARRICK: I am generally familiar with the bills and, yes, they would have a major impact in my opinion, because they address both the standard question, the issue of the dose levels and they also address the interim storage. The interim storage has an impact on the repository because it gives you an opportunity to do things with the feed material to the repository that you wouldn't otherwise be able to do. So, no question in my mind, that

these bills are going to have a major impact if they are approved. At least that's my view.

COMMISSIONER McGAFFIGAN: But have you looked at whether there are additional policy issues that, in your view, need to be resolved? That was one of the questions that I believe our staff received from both houses was, are the policy issues that need to be settled being settled in this bill or are there gaps that we should think about settling?

DR. GARRICK: Well, I think the policy issue that prevails is the same one that we have been talking about.

COMMISSIONER McGAFFIGAN: Human intrusion?

DR. GARRICK: Right.

DR. POMEROY: There are certainly, however, going to be significant issues that arise in any interim storage facility with regard to the infrequent events, particularly seismology and volcanology.

With your permission then, we would like to turn next to a presentation on flow and radionuclide transport and coupled processes by Dr. Hornberger.

DR. HORNBERGER: Given my profession, I am not sure how coherent a presentation I can give without a

chalkboard behind me and a piece of chalk in my hand.

COMMISSIONER DICUS: We can arrange that.

CHAIRMAN JACKSON: I made the migration.

. 26

[Laughter.]

DR. HORNBERGER: The issue of radionuclide transport and coupled processes, these two issues, I think are clearly recognized not only by our committee as important but quite broadly by people in the business. They are key elements in the evaluation of Yucca Mountain as a potential repository site. Both the transport of radionuclides through the vadose zone and through the groundwater pathways in the saturated zone and the interaction of radionuclides with the rocks themselves and recognizing this importance of radionuclide transport, we held a working group meeting in September of 1996 where we heard presentations by a variety of groups on these issues.

I wanted to cover just a bit about the significant issues that came up at our meeting in Las Vegas. One of these, I am sure that you heard probably repeatedly about was the measurement of bomb-pulse chlorine 36 in the ESF. These values are, the elevated values of chlorine 36 are obviously attributed to or can only be interpreted as caused by the flow of water to the level of the repository horizon within the past 50 years, roughly. This is very rapid for flow in the vadose zone at Yucca Mountain and indicates that there is flow and transport in an interconnected series of fractures and faults at Yucca Mountain.

This, of course, really is a significant issue for

. 27

evaluation at Yucca Mountain because it is a difficult -- it is difficult to measure, it is difficult to model, all of the things that have to be done.

CHAIRMAN JACKSON: When Mr. Barrett from DOE -- I'm sorry to interrupt you -- briefed the Commission last week, he seemed to think that these were things that could be engineered around. Has the committee come to any conclusions?

DR. HORNBERGER: The preliminary data we have seen, there is a graph, if you can put up the chlorine 36, on the graph on page 16 in your handout, you can see that these open squares, the ones that are high -- by the way, the background, the dotted line at the bottom is the current background. But, in the past, because of changing conditions there had been elevated levels of chlorine 36 so that really anything below about 1,500 on that left-hand scale can be ruled out as not being bomb-pulse. So it is really these higher values that are important.

The open squares indicate data that were collected on what DOE refers to as a feature basis. That is, they went along and they identified fault zones and that is where they took the samples. And you can see, for the most part, the elevated values of chlorine 36 are associated with these features. That is the basis, I think, of Lake Barrett's conclusion, if we stay away from major fault zones, we may

. 28

be able to avoid these fast flow paths.

Now, having said that, I don't think that the final story has yet been written. There are a variety of isotopes that have to be looked at and we have to hear a lot more about the distances from these fault features where the chlorine 36 has been identified. I think at first blush it looks like an engineering solution might be feasible but it

is a little too early for me to say that with any degree of conviction.

I think what the chlorine 36 data touch on as well, or in coordination with another significant issue that came up at the meeting, is that the infiltration flux through the repository horizon is a really important parameter in determining the performance assessment. DOE had originally speculated that the infiltration rates were very low, the fluxes were very low. From a host of different lines of evidence, this number has been revised and best estimates now are probably that the flux is between one and 10 millimeters per year whereas earlier estimates had placed it at less than one millimeter per year.

This then has significant implications for, as I say, the repository performance, the evaluation of the repository performance. And there is a significant issue as to how much information we have and how much more information we need. I am using the "we" generically. DOE

needs to actually evaluate repository performance. There is precious little actual data on the hydrological characteristics of fractures and faults at Yucca Mountain.

Some other issues that came up at our working group meeting have to do with the chemical state at the repository. It was unclear to us from the presentations we heard to what extent DOE and their contractors were dealing in an integrated way with what we might term the near field chemistry, the fact that there were going to be large quantities of iron, steel, concrete in the repository and actually trying to come to grips with how these materials might buffer the chemistry, the dissolution of the waste forms, the waste packages themselves.

Furthermore, it turns out that with the higher fluxes now being looked at, higher infiltration fluxes through the repository horizon, the importance of the interaction between the radionuclides and the geological materials, the zeolites, the absorption, the geochemical interaction may in fact become more important than previously thought. This is an issue that may assume greater importance in the future.

Finally, we heard some material on colloid transport and we were not convinced that this issue had been resolved, the effect of colloids.

Concerns and advice? Well, in addition to some of

the other concerns that I hinted at, we had a fairly significant concern that DOE and the contractors were developing some very nice what we might call inverted, scientific models. But clearly to go to performance assessment, TSPA, their TSPA, they are going to have to do abstractions. They are going to have to use simplifications. We were concerned about the transparency of that simplification process. In fact, our advice to NRC staff was that the staff really needed to remain aware of both the expert elicitation process and the TSPA abstraction workshops to make sure that they kept tabs on how DOE was doing this so that they would understand the simplifications that had gone on.

The ACNW is concerned about the limitations that had to be placed on the issues related to radionuclide transport at the center. We recognize, really along with the NRC staff, we do understand how these decisions come to be made. But, again, I think you heard from Margaret Federline the ongoing analysis may in fact lead staff to

have to revisit this issue and perhaps revive some of the work that had been put on hold regarding radionuclide transport.

We also had thought that the NRC had supported work at the Apache Lead Research Site at the University of Arizona for many years and we saw a chance that some of

these issues related to colloid transport in particular might be effectively dealt with by additional work at the ALRS.

Finally, I have just a few words to say on coupled processes. You might say I have been talking about coupled processes, hydrology and geochemistry, and that is true. There are other coupled processes that are of some importance.

In particular, the focus on the near field having to do with thermal load in particular, the ACNW sees -- we anticipate that there will be increased use of PA to prioritize emphasis on coupled processes and really to do scoping studies as to really what new data may need to be collected. We see in the letter report that we sent forward, we see this as an area that is "data starved." We have more models than we have data and we think that more data are going to be necessary.

As I mentioned earlier, we see a need for greater emphasis on near field chemistry and also we see a need to keep tabs on the repository design in terms of the thermal load. This has not been set and a linkage between the thermal load and the hydrological response is likely to be a key issue.

That is all I have to say.

CHAIRMAN JACKSON: Zero sum game budgeting can

result in the support of one area of research resulting in eliminating another. So is there an issue under review by the center, the CNWRA, that you would propose being replaced by the work on flow and radionuclide transport and the coupled chemical and hydrologic transport models?

DR. HORNBERGER: You saved the tough question for me, didn't you?

CHAIRMAN JACKSON: I warm up as I go along.

[Laughter.]

DR. HORNBERGER: Obviously, I would have to be very careful in terms of we haven't done a very -- I haven't done a very full analysis of the total center program so I will just give you my own opinion. This is not an ACNW opinion.

I think that, for example, we heard --

CHAIRMAN JACKSON: Commissioner Dicus is giving me a look.

DR. HORNBERGER: Okay.

[Laughter.]

DR. HORNBERGER: We heard about the KTI and igneous activity at our last meeting and we actually, I think, there is room for an orderly closeout, for example, on that issue. I don't know what kind of resources that would save. I don't know whether that would really lead to an improvement of the situation with regard to radionuclide

transport or not but in a zero sum game there aren't any easy choices.

CHAIRMAN JACKSON: Thank you.

Commissioner Rogers?

COMMISSIONER ROGERS: Is there any work going on elsewhere in the world that we might be able to tap into, particularly on these more general questions of coupled processes and colloid chemistry effects?

DR. HORNBERGER: Yes. Colloids and coupled processes have been an emphasis internationally. The difficult bit is, for example, with colloid transport is, to my knowledge, all of the other countries in the world are looking at saturated repositories. So we can learn some things.

It turns out, however, that colloids have a propensity to get hung up on air/water interfaces and you don't have very many air/water interfaces in a saturated granite. So there are some limitations.

So the short answer is, yes, there is a lot to learn. We should definitely keep abreast of what is going on internationally. But there are also some very special things going on a Yucca Mountain.

COMMISSIONER ROGERS: Do you think there are any mechanisms that ought to be put in place to tap these international efforts that are not presently available?

DR. HINZE: One of the things we stated in our coupled process letter is that INTERVAL, the second phase of INTERVAL has a lot of merit and a lot to tell the NRC and the center in our work. One of our recommendations was there seemed to be a lot of bang for the buck, if you will permit me, a lot of things that could be achieved with relatively minor investment. That would also, of course, give the NRC a certain amount of leverage in terms of directing that into those areas that would be of most interest and most concern to a tuff-related repository.

CHAIRMAN JACKSON: Commissioner Dicus?

COMMISSIONER DICUS: Yes, you have pointed and spoken to the importance of the transport and the findings with chlorine 36 and I think in response to the Chairman's question regarding engineering features to perhaps address or resolve the issue. My question goes to more of a shorter term. Would you care to make a comment on what these findings, what might their implications be with the viability assessment?

DR. HORNBERGER: I think that these provide -- these are data that everyone has to take into account. There are two issues, of course. The presence of chlorine 36, of course, indicates there is new water but it doesn't tell us how much new water. Now, the suspicion from the range of other investigations is that the flux is very

small so we are not necessarily talking about a leaking sieve so I think that DOE will certainly have to bound the uncertainties and they will have to investigate this in their viability assessment. But I don't think that this one bit of evidence says, all bets are off, it has to be purely engineering that we rely on.

CHAIRMAN JACKSON: Commissioner McGaffigan?

COMMISSIONER McGAFFIGAN: Just on the issue of funding, when we had Mrs. Federline in a few weeks ago, radionuclide transport was an area where she identified some extra money might be needed. The Chairman has -- I forget whether it is vapors or fumes -- has said our program is working on in a few areas and we clearly hope that we will get some support from the Congress this year to get the full $17 million request and get -- my sense is even if we can close out, if that is appropriate, the igneous activity,

KTI, we still have lots of things where new issues are coming up that we could usefully put some resources into, totally leaving aside an interim storage site if that ever were to emerge. We are totally working on fumes at the moment or darn close to it.

So I just wanted -- the Commission has made it very clear and in testimony, the Chairman's testimony, even at $17 million, we have a very, very, very tightly constrained program.

That's more a statement than a question.

DR. HINZE: I would like to interject something about coupled processes in relationship to that. One of the reasons that we looked at coupled processes is the committee was concerned that there was not a KTI on coupled processes because we think that is a very important item. The Staff folded this into the technical integration, KTI.

But our concern here was that we don't lose the coupled processes because this is potentially extremely important and that the resources, as you were alluding to, are a problem there too. But at least coupled processes are being worked upon in that technical integration. It is a matter of emphasis.

CHAIRMAN JACKSON: Dr. Pomeroy.

DR. POMEROY: We will move right along.

The next item on our agenda has to do with igneous activity and Dr. Hinze will make that presentation. That is under Tab C.1.

DR. HINZE: Since the bottom line has already been given on this --

[Laughter.]

DR. HINZE: Thanks George.

As I think we are all aware, the potential risk from igneous activity has been identified as an important site characterization issue and is appropriately a KTI and

that is because Yucca Mountain lies within what is known as an active volcanic field. Anyone that travels, as you have, to the site sees Lathrop Wells, which has an age date of 100,000 years and perhaps even some less, activity that is less, that is only 15 kilometers away. And we see some of the one-million-year-old activity of Crater Flat, just five miles, eight kilometers away from the site.

Obviously, this makes the likelihood of activity, the probability, extremely important. That, together with the possible entrainment of waste in an eruption could bring waste to the surface and that brings us to the consequences, the other half of the risk ingredient. Additionally, there could be some igneous effect, igneous activity effects that would be indirect and these are part of the coupled process routine as well.

I am sure the Commission is very well aware that historically this is a contentious issue which has reached the popular as well as the scientific press. The major players in this, the three major players, DOE, NRC, as well as the state of Nevada, have all had somewhat differing views which seem to be approaching some kind of commonality. Not exactly commonality, though.

It is important to understand that the reason for this is that the science of prediction of volcanic activity or igneous activity, especially in terms of thousands or

tens of thousands of years, is really very much in its

infancy. It is a difficult problem. And as a result of this limited experience in prediction and also the very low number of igneous events, it works at you both ways there. There are a lot number of igneous events and, as a result, the Yucca Mountain -- the approach to Yucca Mountain igneous activity problem requires that we approach this statistically, look at probability and be very much concerned about the range of uncertainty.

In the next slide, we mentioned a few things regarding our activities. We have been long supporters of a strong NRC program on this topic for confirmatory purposes and have continued to monitor it. And, as mentioned previously, we did hold a meeting, at are last meeting in April, to examine the status of the igneous activity KTI because we are at really a critical stage in that whole process. We were joined by several international experts in volcanology who gave us advice.

The bottom line to all of this is that we believe that the ACNW should -- we conclude that the work on this topic of igneous activity is very much nearing completion and should be brought to an orderly closure within roughly a year. We do have some recommendations for that program and we will -- we are in the process of preparing that in the form of a letter to you which hopefully we will have out at

this meeting.

In terms of the status of the igneous activity and in terms of probability specifically, DOE has closed out its site characterization program with the probabilistic volcanic hazard expert elicitation which, incidentally, came up with about the same mean probability value that the DOE program did. They have also closed out their work on the consequence, the other half, the consequence study.

We don't know very much about that. They have not made presentations to us on their work on this but the synthesis report that they are preparing and will be out at the end of the fiscal year, we are told, will provide us with that kind of information.

Now, DOE and NRC and practically every individual scientist because of the infancy of this "science" have different approaches to estimating the probability. But peer reviewed literature indicates that these are -- that these may all be viable approaches but they are different. And DOE and the NRC don't reach the precise probability value.

The significance of this is important to all of us but it is going to have to wait for follow-on PA work both by DOE and by NRC to put it into the risk RIPB, to the risk-informed, performance-based approach.

The NRC has performed preliminary consequence

estimates. These are excellent preliminary work. The DOE is in the planning stages on this and will be taking this up as part of their TSPA and, as we understand from them, they will be using basically the same codes that the NRC is using in their calculation of risk and those consequence and thus risk.

The NRC continues to fine-tune their work and appropriately they are conducting and should for a short time here should conduct limited -- in our view should conduct limited field work and they are conducting modeling studies to decrease that uncertainty and to test the conceptual models. That is true in both the probability and consequence areas.

I am sure you have heard from DOE and from your own staff the results. Let's just touch on those again. The tentative estimates, and these are still tentative estimates because they are not completely documented and finalized. But the probability is that there -- from the multiple models of the staff and the center have a range of probability of 10 E-7 to 10 E-8 events per year. And what the NRC staff needs to do, in our view, is that they need to finalize this and they also need to develop their range of uncertainty of that value from their studies, from their studies of the models.

Consequences have been performed leading to 500

millirems per year at 20 kilometers at Amargosa Valley. This is from a particular model that deals with waste entrained in an ash-forming eruption. This is -- they have used relatively conservative values in their calculation of this.

The net result, when you look at the risk here for a period of 10,000 years, you end up with a risk that gives you that warm, fuzzy feeling of half a millirem per year over a 10,000-year period of time.

The DOE has estimated as a result of their PVHA a mean probability of 1.5 times E-8 with a bounding range of 10 E-7 to 10 E-10. The PVH estimate and the DOE estimates are something less than an order of magnitude difference. My own personal feeling, and this is my personal feeling, is that considering the fact that the risk is only half a millirem per year based upon the 10 E-7 value, which the staff terms a reasonably conservative upper bound, that the difference here between the PVHA value and the work of your staff is not remarkably different and not terribly significant.

In terms of our conclusions, this is not just the perfunctory congratulatory but we do believe that the NRC has had a very strong program that provides excellent confirmatory expertise. This is a new area and their chaps have really bitten into this and done an excellent job, peer

reviewed articles, et cetera, that have been very well received.

The probability and consequence activities of the NRC need to be prioritized. The work needs to be conducted with dispatch and leading to an orderly closure within a year and that should include complete documentation. We need more documentation.

In order to have some robustness to these results and to have confidence in them, it is important that the probability studies be scrutinized with sensitivity studies and there is a need, potentially a need for the igneous event sites that have been recognized in the immediate Yucca Mountain area, and particularly in Jackass Flats immediately to the east of the repository, these need to be checked out to determine if we have the presence of unrecognized volcanic igneous activity events. This is the one possibility of having a major change, bringing about a major change in the probability. This is not calling for a great deal of work and it would make the results much more robust in the licensing procedure.

Consequence studies are preliminary. We need to have a little more complete range of the scenarios. We don't mean ad infinitum but there needs to be a look at broader scope of the scenarios, particularly the spatial

gradient, the study of the spatial gradient of the dose in
. 43
an ash eruption type of eruption. And any study of any vagaries in the distribution of the ash by wind, for example, we all see the sand dunes in Amargosa Valley and we must be certain that the distribution by winds, for example, may not complicate the situation.

We don't mean to be harping but greater reliance on PA is needed to prioritize the activities in the igneous activity and it still is possible to do that and make that more worthwhile. And also we need some guidance on this particular KTI, on closure of it. What uncertainties are going to be permissible for closure of this KTI?

We do want to pass on the recommendation that there is a need to maintain expertise in igneous activity, to monitor and evaluate the continuing scientific progress in predicting igneous events. This is a very dynamic area, one in which the science is changing at a very steep -- on a very steep gradient and it is possible, I don't know about probable, but certainly it is possible that in this prelicensing period we are going to see some significant changes in the ability to predict igneous events.

So it is important that we maintain an expertise to follow that, to evaluate that and to also be involved in the monitoring of the TSPA-VA of the Department of Energy as well as handling the NRC's own performance assessment work.

We will hopefully be providing you with comments
. 44
and discussion about these individual items, but would be happy to try to answer any questions.

CHAIRMAN JACKSON: Commissioner Rogers?

COMMISSIONER ROGERS: I have no additional questions.

CHAIRMAN JACKSON: Commissioner Dicus?

COMMISSIONER DICUS: No questions.

CHAIRMAN JACKSON: Commissioner McGaffigan?

COMMISSIONER McGAFFIGAN: Again, a comment. Another reason we may need to maintain expertise is when we ever get a license application in this area we need someone who remembers why we closed it out the way we did in 1998.

DR. HINZE: Yes, sir. And I think my colleagues said that I should say "documentation" at least five times during my presentation. I don't know whether I made five times but I wanted to.

CHAIRMAN JACKSON: So that in the year 2040, we can --

[Laughter.]

DR. HINZE: Well, we won't see it.

Thank you very much.

CHAIRMAN JACKSON: Thank you.

Dr. Pomeroy?

DR. POMEROY: I would only like to reemphasize one point that Bill made. That, again, the spatial distribution
. 45
and the sensitivity studies in the igneous activity area are extremely important and those certainly should be carried out. We are looking forward eagerly to getting the results of those to evaluate what potential effect, for example, as I talked before, the location of the critical group might make on that.

The last item on our agenda, for which we have about five minutes, is myself. I would like to talk very briefly about some selected topics from our priority issues.

I would like to talk about issues that -- some of

these issues fall somewhat peripherally within our framework and have a lesser relationship to the main body of the work that we carry out.

I would like to call your attention to the comments regarding agreement states issues on page 5 and page 6. I would like not to read them to you. I think we can all read.

These are things that keep coming up in our discussions, areas where we find that there is a lack of evidence for a given problem and we continue to maintain them on our list of potential topics for the future.

What I would like to talk about very briefly is the expert judgment slide, slide number 7. Namely, I believe and we are seeing evidence of this, that expert judgment continues to play an important role in the

. 46

decisionmaking process. You heard Bill discuss the probabilistic volcanic hazard assessment.

There are concerns within the probabilistic volcanic hazard assessment that are perhaps broader than simply that one assessment, mainly the question of incorporation of new data. As Dr. Garrick has pointed out, there are methodologies for handling the incorporation of new data into an expert elicitation. Those are methodologies that are available, they have been exercised in the PVHA program. It is more difficult to incorporate a paradigm shift conceptual model but, even there, there are helps that may come from the PRA field with regard to that.

The point I would like to stress here is the question of communications between the DOE and the NRC staff. We have seen improvements in the communications between those two entities but we believe there is a great deal of improvement that still could be made.

Specifically, I personally find what I see is a talking past each other phenomenon that is common with younger persons in general.

[Laughter.]

COMMISSIONER ROGERS: Does that include us?

DR. POMEROY: No.

COMMISSIONER ROGERS: I thought that was a technique that developed with age.

. 47

DR. POMEROY: I don't want to comment on the DOE's half of this game but I do feel there is a need for the NRC to evaluate elicitations that it does receive. I feel there is a need to respond and to comment on any DOE initiatives that are undertaken as a result of requests from the NRC. I feel very strongly that there should be clear statements of the criteria that are going to be used for closure of a given issue and I have to say that, in spite of our working group meeting and in spite of attending the technical exchange, I would still need a statement of the "official" NRC position. I am unable to determine that at this time.

CHAIRMAN JACKSON: The official NRC position on?

DR. POMEROY: On igneous activity, on the closure of igneous activity, what their actual numbers are. These are often presented by members of the center staff who, of course, do not speak for the NRC staff and a clear statement of the NRC position was one of the objectives that we had for our working group session. We hope the improvement that we have seen in communications will result in further communication in the future.

CHAIRMAN JACKSON: Thank you.

DR. POMEROY: I believe that is all I would like to say, except to say I hope you can discern out of what we have presented here today two themes. One is that we strongly support risk-informed performance-based regulation

and, secondly, that we support the use of scientific and technical data to the maximum extent possible in formulating all of our responses and regulations.

I think that is all we have.

CHAIRMAN JACKSON: Further questions?

COMMISSIONER ROGERS: Just on this expert judgment topic which has, I think, always been an interesting and challenging one as to how to use it, I wonder if you could say anything more about the use of expert judgment in those areas where there might be some kind of scientific disagreements. It looks as if this has worked pretty well, particularly in the igneous area, as far as I can learn. I know you touched on the issue of human intrusion as not being a scientific question and I am not introducing the notion that expert judgment could help very much in that one. I mean, I have set that one aside, I don't know.

But in other areas, it seems to me there is a gradation from a lot of knowledge and a lot of data to a little data and a lot of experience in some ways but not necessarily that much data. And the issue of, is it possible to collect more data to pin things down versus coming to a decision that is probably very difficult to get more data although, if one waited, you know, another hundred years or so you could get more data.

I wonder if you have any thoughts as to how one

might structure the use of expert judgment in coming to -- I hate to use the word "closure" because closure has certain connotations here. But at least coming to a common assessment that at this particular time nothing more in required. Let's call it whatever you want to call it, but I wouldn't call it closure because closure really seems to connote that it really is a settled issue with NRC and nothing is settled until everything gets looked at together, you know, as we have said many times.

So I wonder if you have any thoughts on how to perhaps adopt a little more structured approach to the use of expert judgment that would help in somehow or other deciding we have come to the point that nothing more is required right now?

DR. POMEROY: Let me offer a few comments. I am not sure I can answer that question completely but let me say first there are, of course, as you are well aware, other assessments or elicitations going on at the present time. The probabilistic siting hazard assessment and a number of assessments in association with the abstraction process of TSPA and also simply an elicitation of experts in various areas like the unsaturated zone hydrology.

In the unsaturated zone hydrology workshop, the experts themselves were given the question. Do you see the need for additional data and, if so, what additional data do

you see? They got some very positive responses that there was a need for additional data and so that feedback occurred within the expert elicitation process.

We have long discussed among ourselves the question of how expert elicitation is going to be accepted in the legal or adversarial, at least, environment that we will eventually be functioning in and at one point we felt

very strongly and I think I personally still do that we should attempt to try to formulate a rulemaking process, in fact, that we feel at that point that guidance was not sufficient.

There are questions, some legitimate questions that the staff has raised with regard to PVHA that aren't easily decidable in terms of how do you select experts, how do you ensure that there is a full spread that the people who are involved in the process can provide you the full range of uncertainty in the given process that you are looking at.

Some of those could be answered by a more formalized structure for the use of expert judgment. I believe that there are discussions within the NRC staff itself as to the relative -- still, as to the relative value of the expert judgment elicitation, formal elicitation process. That is a good thing to have. But we need at some point to reach some consensus on those in terms of moving

. 51

the process forward.

I think if you have looked at Dr. Brocoum's slides from a recent management meeting, those are -- those indicate clearly that there is a problem between what DOE sees as the value of the expert judgment elicitations and what he perceives as the NRC response to those questions.

I think there is still room for improvement here and we need to work still with the various groups to see whether we can't formulate some of that.

DR. GARRICK: I think I would like to make one comment on the whole issue of expert judgment. One of the things that I have observed as that as we work harder to develop a schema for expert elicitation, it seems that one of the fallouts of that is that we discover new ways of finding information.

I am thinking, for example, of a non-NRC facility where, in its early days of analysis, namely the Waste Isolation Pilot Plant, there was heavy dependence upon expert elicitation. And what happened was as the expert elicitation took place and was highly criticized in most cases, especially that having to do with future societies, it did sharpen the wits and the creativity of the investigators on how to find data to at least narrow the issues that -- on which they would have to do expert elicitations.

. 52

So it has had an interesting side effect of sharpening up the ability to scope issues such that maybe there is more information than one thought. You know, a simple analogy would be if you are asked to analyze a first-of-a-kind system for which there is no data, you don't know quite where to start. But if, on the other hand, you start looking at that system and breaking it apart and you find at the subsystem and component level there is lots of information, then it becomes a matter of how well you can aggregate that into the total system and I think there is some of that kind of benefit that has come from the expert elicitation exercises.

CHAIRMAN JACKSON: Commissioner Dicus?

COMMISSIONER DICUS: No, thank you.

CHAIRMAN JACKSON: Commissioner McGaffigan?

COMMISSIONER McGAFFIGAN: I would like to go to a slide that you skipped past under B.1, number 6, on decommissioning nonreactor facilities. I want to precede

this by thanking you for the letter that you sent last month with regard to the decommissioning rule and the appropriateness of the 25 millirem per year all pathways standard that is proposed by the staff and not having a separate groundwater standard.

But this first bullet on that page, the notion that we as a government may need to think about getting all

of this waste activity into a single home is one that I haven't seen before but, given what I know now, it rings true to me. NORM, the NORM issue which you cite in your parentheses there, there are lots of NORM sites around this country that are at least as dirty as anything that we are going to try to clean up under the rule that you commented on last month. Yet they are unregulated at the moment, effectively. We argue about what NORM is and technologically enhanced NORM and the various fossil industries come in and say, you know, not us. And we even have a letter on record from the American Petroleum Institute saying, you know, please don't ever apply that standard to us, the 25 millirem per year all pathways.

Have you gone any further? Is there anything behind this bullet other than a plea for rationality?

DR. POMEROY: The simple answer to that is, not a great deal. It is a statement of rationality that we came to in the process of looking at the low-level waste program which we responded to earlier.

When we began to look at that in an examination of many of the other activities that we have looked at in the past, one comes to the immediate conclusion that there needs to be a rational order placed on this and it seems intuitively obvious to us, perhaps, that such a thing should happen, that the NRC should be responsible for all

radiological wastes and that there should be a single entity governing that.

COMMISSIONER McGAFFIGAN: But that would require an amendment to the Atomic Energy Act.

DR. POMEROY: That's certainly true. We recognize that.

[Laughter.]

DR. POMEROY: The laugher means that's impossible?

CHAIRMAN JACKSON: No, no. A private joke here.

On behalf of the Commission let me thank you and commend you for a very high-quality briefing. The committee's deliberations and advice will be of tremendous benefit to us as we grapple with the issues particularly related to licensing of a high-level waste repository. So the Commission greatly appreciates all of your efforts in those areas as well as the others and that was a particularly nice walk through from the perspective of the committee's views on risk-informed performance-based regulation, which is always a favorite topic.

So, unless there are further comments, we are adjourned.

[Whereupon, at 3:32 p.m., the meeting was adjourned.]