# Official Transcript of Proceedings ACNWT-0185

# NUCLEAR REGULATORY COMMISSION

ORIGINAL

Title: Advisory Committee on Nuclear Waste 165th Meeting

PROCESS USING ADAMS
TEMPLATE: ACRS/ACNW-005

SISP - REVIEW COMPLETE

Docket Number: (not applicable)

Location: Rockville, Maryland

Date: Monday, November 14, 2005

Work Order No.: NRC-742

Pages 1-205

**NEAL R. GROSS AND CO., INC.**
**Court Reporters and Transcribers**
**1323 Rhode Island Avenue, N.W.**
**Washington, D.C. 20005**
**(202) 234-4433**

TR08

ACNW OFFICE COPY - RETAIN FOR THE LIFE OF THE COMMITTEE

# DISCLAIMER

UNITED STATES NUCLEAR REGULATORY COMMISSION'S

ADVISORY COMMITTEE ON NUCLEAR WASTE

November 14, 2005

The contents of this transcript of the proceeding of the United States Nuclear Regulatory Commission Advisory Committee on Nuclear Waste, taken on November 14, 2005, as reported herein, is a record of the discussions recorded at the meeting held on the above date.

This transcript has not been reviewed, corrected and edited and it may contain inaccuracies.

UNITED STATES OF AMERICA

NUCLEAR REGULATORY COMMISSION

+ + + + +

ADVISORY COMMITTEE ON NUCLEAR WASTE (ACNW)

+ + + + +

165th MEETING

+ + + + +

MONDAY,

NOVEMBER 14, 2005

+ + + + +

ROCKVILLE, MARYLAND

+ + + + +

The Advisory Committee met at the Nuclear Regulatory Commission, Two White Flint North, Room T2B3, 11545 Rockville Pike, at 8:30 a.m., Michael T. Ryan, Chairman, presiding.

COMMITTEE MEMBERS:

MICHAEL T. RYAN, Chairman

ALLEN G. CROFF, Vice Chairman

JOHN T. LARKINS, Executive Director

JAMES H. CLARKE, Member

WILLIAM J. HINZE, Member

RUTH F. WEINER, Member

ACNW STAFF:

NEIL M. COLEMAN

JOHN FLACK

LATIF S. HAMDAN

MICHAEL LEE

RICHARD K. MAJOR

MICHAEL SCOTT

SHARON A. STEELE

ALSO PRESENT:

JANET KOTRA, NMSS

TIM McCARTIN, NMSS

DADE W. MOELLER, Dade Moeller and Associates

THOMAS TENFORDE, NCRP

MATTHEW KOZAK, EPRI

MARTIN MALSCH, ESQ., State of Nevada

# I-N-D-E-X

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

(8:36 a.m.)

CHAIRMAN RYAN: This is the first day of the 165th meeting of the Advisory Committee on Nuclear Waste.

My name is Michael Ryan, Chairman of the ACNW. The other members of the committee present are Vice Chairman Allen Croff, Ruth Weiner, James Clarke, and William Hinze.

Today the committee will receive a report from ACNW member Dr. Ruth Weiner, who attended the U.S. EPA's October 2005 public meeting on the proposed revisions to 40 CFR 197. We will discuss the U.S. Nuclear Regulatory Commission's plans for the implementation of a dose standard after 10,000 years.

We'll hear presentations and comments from stakeholders on revisions being proposed to the Yucca Mountain regulatory framework. We'll hold an ACNW roundtable discussion later in the day on the matters discussed in the morning and early afternoon sessions. And we will discuss proposed committee letters and reports.

Mike Lee is the Designated Federal Official for today's session.

This meeting is being conducted in

accordance with the provisions of the Federal Advisory Committee Act. We have received no written statements or requests for time to make oral statements from members of the public regarding today's sessions, other than those already on the agenda.

And 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 clarity and volume so they can be readily heard.

It is also requested that if you have cell phones or pagers that you kindly turn them off.

Thank you very much.

And without further ado, I'll introduce our first speaker, ACNW Member Dr. Ruth Weiner, who is going to share with us her observations from the U.S. Environmental Protection Agency's October 2005 public meeting on its proposed revisions to 40 CFR 197.

Good morning, Ruth, and thank you.

MEMBER WEINER: Thank you, Mr. Chairman. I want to make it very clear that these were my impressions. I sat through the meetings and took notes, and this is in no way an official record of the hearing.

The way that these meetings -- public meetings and hearings are conducted is that there is a relatively informal roundtable session that goes on for about an hour before the formal hearing. The informal session gives people a chance to ask EPA questions and get informal answers, and to make points.

As it turns out, many -- in fact, I would say all of the people who spoke at the informal session then went ahead and made the same points for the public hearing.

Should I just do my own slides here, or -- oh, okay.

These are just some statistics. The evening meeting was much better attended than the meeting the following morning. I did not stay for the third day.

About 50 people came, exclusive of the various federal observers, and there was a demonstration and I picked up a number of handouts, which Mike Lee has. We're going to scan them and attach them as a .gif file to the final report, if you wanted to look at them. They were hard copy handouts. I was not in a position to do anything electronically with them.

The following morning there was an open meeting at 10:00, and about 20 people attended, exclusive of the EPA people.

Next slide, please.

Should I just do this? Yes, okay.

The major points were made by EPA in response to questions. They reviewed the history of the standard, the role of EPA in the Nuclear Waste Policy Act, and the basic points in 40 CFR Part 197, explained the court's decision to vacate the 10,000-year standard and explained how the new standard was arrived at.

The major points made by EPA were the following: 350 millirem a year was chosen because much of the State of Colorado has a background of about 700 millirem per year. I might point out this is EPA's contention. I made no judgment about whether they were right or wrong.

And I thought their argument was quite interesting. Colorado has very similar demographics to Nevada, very similar climate, very similar geography. So they took Colorado as a comparative state.

Pointed out that 36 states have a higher background radiation than the average United States background, and they said that international standards were consulted, though they went into no detail about what countries, what particular international standards were consulted.

The speakers made a number of points, and the two that I thought were the most critical to the discussion of the standard -- and this is my own personal choice of importance -- the first was that EPA has chosen the median rather than the mean for the longer time period, from 10,000 years to a million years. And, of course, choosing the median greatly increases the allowed upper limit to the dose from the repository.

Many of the speakers, almost all of the speakers, reiterated this point that they objected to the choice of the media rather than the mean. And I might say there was no particular explanation given for this, that I heard in any case.

The second point that I thought was quite important was EPA has been in the past very firm that 15 millirem per year was the largest dose that could protect health. And the question was raised by many speakers: how can you say that before 10,000 years 15 millirem per year is the highest you can go? And now, after 10,000 years, it's okay to go to 350 millirem per year, that that is now adequately protected. The step function aspect of the new standard was what came into question.

The tribal speakers made a number of interesting points. There were several members of various Native American tribes there, and they all made approximately the same points. In particular, the Western Shoshone said this is their land, traditional land, and they don't want to poison it. All of the tribal speakers pointed out that members of the tribe have become ill since nuclear weapons were developed.

They pointed to a lack of logic that went into writing the new standard, particularly focusing on that 15 millirem per year, 350 millirem per year dichotomy. Other standards are not nearly as lenient as the proposed million year standards. And, finally, they said that to take into account the tribal communications with the tribes, the comment period should be extended for a matter of years, not just 90 days.

State and local governments made several additional points, and I want to point out these were additional to the points that everyone made.

The Nevada Attorney General and Governor

Guinn's representative, Mr. Loux, pointed out -- or claimed that EPA had developed the standards in collusion with the Department of Energy, that EPA has abandoned its responsibility to protect public health. They feel that an entirely new rule is needed.

Clark County gave a history of the activities of the Atomic Energy Commission in Nevada, and showed -- said that this showed that people -- the reason why people don't trust the government.

Several organization speakers were up. The Sierra Club made the point that EPA is cooking the numbers. That was their term, not mine, by changing from mean dose to the median. That using the median means "a statistical 100 percent chance of cancer." That was their concern.

That the standard showed no concern about radiation effects on non-human species. They suggested/recommended that the waste be left at the powerplants, that spent fuel be recycled, and said that transportation is harmful to the public.

And a two-tier standard, the word that the Sierra Club representative used, was that it was not stable.

Citizen Alert made the same points everyone else had made, and then said that the hearing

-- the public comment period was not an open process, and said that EPA's fix to the standard subsequent to the core position was totally unacceptable.

Several speakers had a completely different perspective. The speakers -- most of the 50 people who attended were in one way or another opposed to the repository, opposed to/critical of EPA.

A professor from University of Nevada Las Vegas made the point that 15 millirem per year is too small. It's too conservative, in effect, and said we spend too much money protecting against fictional risk. If 10 rem doesn't seem to cause health effects, why are we wasting the public's money on this? Ten thousand years is not set for any other pollutant. The time scale should be shorter, not longer, and we need international cooperation.

Two former test site workers testified that -- and the primary points they made were Hiroshima is currently a big city, people live there, and without any apparent detriment to their health, and made the point nobody is going to build a big city at Mercury, Nevada.

One member said -- and this was almost a quote, it was just too good to pass up. "I'm pushing 80, and none of us are dead, and we're in pretty good shape."

Both of them -- both of the test site workers said that Yucca Mountain is a necessity.

And that ends my report. I'd be happy to answer any questions, comments.

CHAIRMAN RYAN: Questions? Yes, Jim.

MEMBER CLARKE: Ruth, I think it's your slide 8 -- one of the comments was the standard should have been more stringent than 15. Was that all-inclusive or just for the 10,000 to a million?

MEMBER WEINER: They didn't say. I think that the idea was just for the -- for the entire period.

MEMBER CLARKE: For the entire period.

MEMBER WEINER: It should be strict -- whatever it was, the number was too big.

CHAIRMAN RYAN: Bill, questions? Anybody else? Latif?

MR. HAMDAN: Yes. Ruth, did the omission of the barometer standard beyond 10,000 years -- was it in the discussion at all?

MEMBER WEINER: I think it was very casually mentioned, and that's why I didn't put it on the slide. As I recall, one speaker mentioned it, and I -- I didn't have it in my notes, so I didn't put it on the slide. So it was a very passing mention of that.

That did not seem -- the details did not -- that particular detail did not seem to be of enormous concern, even to the Governor's representative.

CHAIRMAN RYAN: Any other questions?

Well, thanks, Ruth. I think we're going to hear some interesting insights through the day on the technical aspects of some of the issues that you raise, and I'll look forward to hearing some of those technical points as we go through the morning.

Next on the agenda we are -- we will hear from U.S. Nuclear Regulatory Commission on plans for implementation of a dose standard after 10,000 years.

Good morning.

DR. KOTRA: Good morning. Good morning, Mr. Chairman, members of the committee. It's a pleasure to be here, and I welcome the opportunity to give a -- provide an overview of --

CHAIRMAN RYAN: And, I'm sorry, this is Dr. Janet Kotra. I forgot to introduce you when you came in.

Thank you. Good morning.

DR. KOTRA: It's working here.

CHAIRMAN RYAN: Oh, the bulb is burned out. Okay. I thought we were --

(Laughter.)

-- at one of those exciting pauses there. Why don't we go off the record for a few minutes, and we'll resume here in just a minute.

Thanks. Everybody just hold your spot, and we'll change the bulb, and on we go.

(Whereupon, the proceedings in the foregoing matter went off the record at 9:50 a.m. and went back on the record at 9:57 a.m.)

CHAIRMAN RYAN: Here we are with Plan B.

DR. KOTRA: Thank you very much.

CHAIRMAN RYAN: Thank you.

DR. KOTRA: I welcome the opportunity to be with you here today, and to provide an overview of NRC's proposed regulations as we have revised them recently.

I assisted Tim McCartin, who had to leave, in drafting these proposed regulations, along with representatives of the technical staff, the Office of General Counsel, and technical support from the Center for Nuclear Waste Regulatory Analysis.

As you know, these revisions are necessary to make our regulations consistent with the new EPA standards governing doses that might be received more than 10,000 years at the potential -- after disposal at the potential repository at Yucca Mountain.

The comment period for both proposals have been extended, as you may know, and I urge any members in the audience today that may wish to comment on either proposal to be sure to submit their comments to EPA by November 21st, or to NRC by the 7th of December. To that end, I've brought with me a number of sheets that have the relevant addresses and closing of the comment period dates. They're in the back of the room, for anyone who wishes to pick them up.

With that taken care of, I want to touch briefly on the proposed -- the purpose of our proposed rule, which is, first and foremost, to implement the new standards. The Nuclear Waste Policy Act, and later the Energy Policy Act of 1982, required that the -- 1992, excuse me -- require that NRC and technical licensing criteria for the Yucca Mountain proposed repository be consistent with EPA environmental standards.

In other words, the Congress has assigned the responsibility for making the risk management decision with regard to the appropriate level of radiation protection for potential releases of the repository to the Environmental Protection Agency.

It is NRC's job, then, to modify our regulations to be consistent with final EPA standards when they are published, and to implement them as part of NRC's licensing process.

In its proposal, EPA specified that NRC provide a treatment for climate change at Yucca Mountain in the period between 10,000 years and a million years. The second purpose of our proposal is to designate a specific range of values that DOE must use when assessing repository performance in order to account for the effects of climate change.

And, lastly, because the proposed rule specifies that estimates of public doses be based upon current dosimetry, the NRC proposal makes provision for the same current weighting factors to be used for both calculations of worker dose and public dose, consistent with EPA's proposal.

Before I discuss these in any more detail, I wanted to give a little bit of background. I'll go through this very quickly, as I'm sure the committee is well aware of it -- that the NRC issued its final regulations for Yucca Mountain Part 63 in November of 2001.

They implement the final standards that EPA put in place in June of that year, and that EPA, in developing these standards, was obligated under the law to make them based on and consistent with findings and recommendations of the National Academy of Sciences.

The State of Nevada and other parties challenged EPA's standards and NRC's regulations in court, and the court upheld EPA's standards and NRC's regulations on all but one issue. As you know, the court disagreed with EPA's specification and NRC's adoption of a 10,000-year compliance period, and remanded the standard to EPA.

The court found that EPA's compliance period was not, in fact, based on and consistent with the National Academy findings as required by law.

To address the court decision, EPA proposed revisions to its standards last August, and NRC must now revise Part 63 to be consistent with the final standards when EPA issues them.

In response to the ruling, EPA proposed these standards, as I said, in August, and we are prepared to revise Part 63 to be consistent.

The general overview of EPA's proposed approach -- and it's not my intent to explain or discuss EPA's standards here -- but they, first and foremost, continue to apply the existing standards for the first 10,000 years after disposal. They have left the existing standard undisturbed for that first 10,000 years.

They have added separate additional requirements for the peak dose after 10,000 years within what they call the period of geologic stability, which they have defined as one million years after disposal. And as I indicated earlier, they intend to update all calculations of doses to the public based upon current dosimetry.

They limit the peak dose after 10,000 years. The EPA proposal specifies criteria that the Department of Energy must use in its performance assessment whereby this peak dose is calculated for estimating doses in this -- these outyears. They specify weighting factors in a separate table in Appendix A of the standard for calculating individual dose, and they state that NRC should specify values that DOE should use to represent the variation in climate in these outyears.

The EPA proposal, as Dr. Weiner indicated and they discussed in their public meetings in Nevada in October, would limit the median value of this peak dose -- these peak dose estimates to 3.5 millisieverts per year or 350 millirems per year. NRC has proposed to incorporate this dose limit into Part 63.

EPA has also proposed that the performance assessments done for the first 10,000 years are suitable as a basis for projections beyond 10,000 years, with some additional specifications. To limit uncertainty, they make these specifications dealing with the treatment of features, events, and processes, often known as FEPs, that need to be evaluated in these performance assessments beyond 10,000 years. In particular, they include seismic activity, igneous events, climate variation, and general corrosion.

Again, NRC proposes to incorporate these criteria in Part 63.

As many of you know, dosimetry has advanced, and international recommendations and standards with regard to weighting factors have advanced, and EPA has proposed the use of current dosimetry in making the calculations of dose to members of the public.

They have included a separate Appendix A to 40 CFR 197 that includes these weighting factors, and indicated that the Department of Energy should use these weighting factors in making their calculations.

The NRC proposes to adopt the specification in Part 63, and we go on recognizing that the EPA environmental and public health standards address only doses to the public. Our implementing regulations also cover doses to workers during operations and closure activities. So consistent with EPA's proposal, we would extend the application of these current weighting factors to the calculations and insist that the same weighting factors be used for calculating doses to both populations.

Perhaps the more interesting, from our point of view in terms of the area where we were given some latitude, was to determine how climate variation should be handled in these very long -- long-term projections.

The EPA specified that the Department was to assume that climate change after 10,000 years resulted -- that the effects of that climate change resulted solely from increased water flow through the repository, and directed NRC to specify steady-state values for DOE to use in projecting the long-term impact of climate change.

In studying EPA's proposal, we considered what parameter or set of parameters would be best to reflect the average climate conditions. The obvious choices are rainfall and temperature, but, really, when you think about it it is the deep percolation to the repository horizon that really affects the performance of the repository.

And, therefore, the Commission chose to specify a range of values for deep percolation rate and assume a log normally, uniformly distributed range, with a mean value approximately six times the current range.

Now, you need to be careful. This is a little bit tricky, because the assumption is here that with each iteration of its performance assessment the Department would sample over this specified range. It would sample over this specified range to select a constant for that iteration, but they would not apply that constant for all iterations. Each iteration would sample again.

So, and this range would represent cooler and wetter climates, which paleoclimate data suggests that over the last million or so years that climate at Yucca Mountain has been cooler and wetter. For this reason, the Commission has proposed a range of values that represent a cooler and wetter climate consistent with what we know has been the case at Yucca Mountain in the past.

In summary, our proposal is to adopt the EPA limit for peak dose after 10,000 years, adopt the EPA criteria limiting the consideration of features, events, and processes to be used in performance assessment for doses after 10,000 years, adopt the EPA weighting factors for calculating individual doses, and require that those same current weighting factors be used for calculating worker doses as well.

And, lastly, and you will hear more about this in your meeting in December on the details of how we selected a method for projecting long-term impact of climate variation, we will have other members of the technical staff, as well as someone from the Center for Nuclear Waste Regulatory Analysis, to go into a little bit more detail for the technical basis for making this selection.

But suffice it to say that in our proposal we have designated a range of values over which the Department must select in projecting a long-term impact of climate in the 10,000 to one million timeframe.

In closing, I want to leave you with the message that the NRC continues to believe that its existing regulations at Part 63 are protective. We have proposed additional requirements on top of those protective standards and regulations that are consistent with EPA's new proposal for Yucca Mountain. And that the NRC stands ready to revise its regulation to be consistent with final EPA standards when they are issued.

And with that, I am happy to answer any questions. And Tim McCartin, the chief author, is also here with me today. And I'm sure he will be happy to address your questions as well.

Thank you.

CHAIRMAN RYAN: Thanks, Dr. Kotra. We appreciate this summary of your activities to date. I think we recognize, too, that while the comment period for the EPA standard is underway and ongoing, that that means that what you've based your efforts on so far may, in fact, change some perhaps, perhaps not. Who knows?

So it's a -- in that spirit, I think I'll ask you questions about where you are in time.

DR. KOTRA: Okay.

CHAIRMAN RYAN: My question, as you were talking about the worker calculation, led me to think immediately about 10 CFR 20. Are you going to make the same change for weighting factors across the board?

DR. KOTRA: At this point, no. Our proposal is limited to Part 63 because of the requirement that we be consistent with EPA's proposal.

CHAIRMAN RYAN: I guess I haven't thought enough about it, but it would be interesting to explore what that means, because if -- if you use different weighting factors, that has to go through the entire system of ALIs and DACs and all the rest.

DR. KOTRA: We recognize that.

CHAIRMAN RYAN: So that would be a huge overhaul of radiation protection requirements, and I just -- I wonder if it's worth thinking about that a little bit more. Maybe you have already, Tim.

MR. McCARTIN: The wording in our regulation was chosen very particular, and the weighting factors will be used for the calculation of doses. And so when you're doing the preclosure safety assessment where you're calculating worker doses, you would use those weighting factors in the calculation.

Now, in terms of Part 20, other things that are in Part 20 that are not calculating would not use those weighting factors. And so we're interested in getting public comment -- the words "calculation" were chosen very deliberately. It's for the calculation of doses and --

CHAIRMAN RYAN: I hear you, but I think that meaning is not going to be readily apparent to the average person who is operating under 10 CFR 20 or an agreement state equivalent, and --

MR. McCARTIN: Well, certainly. But this rule only applies to Yucca Mountain. So agreement states and other -- this is not a change to --

CHAIRMAN RYAN: I hear you, but --

MR. McCARTIN: -- the application of Part 20 to other facilities.

CHAIRMAN RYAN: -- we all reach for the most recent dosimetry whenever we have to make a calculation. So let me just throw out a for instance. I'm a licensee, and I have an internal exposure to assess. Do I use the NRC's Part 20, or do I rely on the most recent thinking, which happens to be applied in 63 to Yucca Mountain, but seemingly would reflect what they view to be appropriate science?

DR. KOTRA: It is my understanding that many licensees have applied for and readily received exemptions to use the more current dosimetry.

CHAIRMAN RYAN: Some. I wouldn't say many perhaps, but -- but I guess I just -- I just want to think a minute about, and probably more than a minute, about, you know, is there an appropriate way to deal with that.

I'm also mindful of the fact that in a previous letter we addressed neutron, you know, dose factors, and so forth, that the ICRP recommended and talked about that at an appropriate time when regulations were changed for another reason that might be a good place to pick that up. So I'm -- want more to think about.

But I think it is an issue to very carefully either deal with it, so it's clear it doesn't mean people that use 20 for worker protection, you know, have to change, but you can see immediately there's a conundrum here that workers at a repository will be looking at something different than the performance assessment calculations which licensed it.

DR. KOTRA: Dr. Ryan, I'd like to also add that we recognize that this is a long-term program, and EPA recognized it and explicitly gave NRC the latitude in its proposal to require even new -- newer dosimetry, should that become available before the repository is operational.

So the EPA recognized that this is sort of a moving target as to the time --

CHAIRMAN RYAN: Sure.

DR. KOTRA: -- and that the NRC could,

under Part 63, specify -- make another revision and specify even newer factors, should they emerge.

CHAIRMAN RYAN: You know, it has roughly been, what, every 15 years or so we get a new set of stuff from ICRP. So it's worth perhaps some detailed thought on --

MR. McCARTIN: Sure.

CHAIRMAN RYAN: -- how the use of and updating of and implementation of all this might flow.

MR. McCARTIN: Right. But certainly the intention was we were not in any way affecting the application of Part 20 by this change in --

CHAIRMAN RYAN: And, in particular, DACs and ALIs and all those radiation protection activities --

MR. McCARTIN: Right. That's why --

CHAIRMAN RYAN: -- and so forth.

MR. McCARTIN: Yes.

CHAIRMAN RYAN: Maybe saying that actually explicitly would be --

MR. McCARTIN: Well, certainly the Yucca Mountain standard in itself, in the preamble, is that this is a regulation that's applicable to Yucca Mountain period. It doesn't even apply to another high-level waste facility.

CHAIRMAN RYAN: Right.

MR. McCARTIN: So, I mean, it --

CHAIRMAN RYAN: Okay. Well, again, I just think the clearer and more transparent it can be the better.

MR. McCARTIN: Yes.

DR. KOTRA: We'll take that to heart. Thank you.

CHAIRMAN RYAN: Let's see. Bill?

MEMBER HINZE: Janet, my recollection is that the NRC did comment on the original regulation 197.

DR. KOTRA: Yes, we did.

MEMBER HINZE: Is it the plans of the NRC to make any comments to the EPA on their proposed standard?

DR. KOTRA: As far as we were aware, the Commission has no intent to comment.

MEMBER HINZE: I see. I'm curious about these peak doses. Reading from some of the NRC material, for this comparison -- that is, the comparison to the 350 millirems -- for this comparison, EPA proposes that DOE use the median value of the dose distribution of peak doses -- doses -- after 10,000 years.

What evidence do we have that there are going to be multiple doses in that period of time?

DR. KOTRA: I think what's referred to there is the multiple iterations that are done.

MEMBER HINZE: The multiple iterations. Okay.

DR. KOTRA: And then, you get dose estimates.

MEMBER HINZE: Okay. Is there any evidence that there will be multiple doses in any of the preliminary performance assessments out to a million years?

DR. KOTRA: Since I'm not sure I understand that question, Tim, would you like to --

MR. McCARTIN: Do you mean --

MEMBER HINZE: Is there any evidence that there will be --

MR. McCARTIN: -- more than one --

MEMBER HINZE: -- more than one peak dose?

DR. KOTRA: Oh, okay, more than one peak.

MEMBER HINZE: There's a volcanic effect after a few thousand years, that peak dose, and then we continue on. And I'm wondering --

MR. McCARTIN: Yes. By definition, I think we would say there can only be one peak. Now, the dose -- it isn't necessarily one smooth rise to a peak dose and a drop. It could be more rollercoaster-ish if you will that it goes up and comes down, as different nuclides come in and go out.

But overall there can only be one where it's the largest, most -- you know --

MEMBER HINZE: But is there any evidence that there are these local peaks?

MR. McCARTIN: Well, certainly, I mean, you bring up the prime one that -- that the dose curve we're talking about is the composite dose curve of all the scenarios. So clearly igneous activity, which has the potential to produce a dose early on, will have a -- some type of what I'll call a local peak in the first, let's say, couple thousand years.

MEMBER HINZE: Right.

MR. McCARTIN: Later on there could be another local peak due to -- that may be the actual peak due to neptunium and some other slower transported things in the groundwater. But, you know, which one actually dominates depends in part on the analysis, and certainly the newer dosimetry will have an impact on that also. But the curve is certainly more like a rollercoaster --

MEMBER HINZE: Right.

MR. McCARTIN: -- that you would expect to see a few undulations, or it's certainly not gradually up and then down.

DR. KOTRA: There's nothing in either the EPA standard or the NRC regulations that presumes any particular shape. It just says whatever the highest value is in that period, we call that the peak dose. And so that would be, as Tim indicated, the result of a composite of all the scenarios.

MR. McCARTIN: And that's why you certainly need to do the calculation out to a million years, because prior to that you're not going to know, well, did the peak occur at 10,000 years, 200,000 years, 500,000 years. Until you actually do it, you won't know.

MEMBER HINZE: Let me ask a question about the climate change. And I understand that we're going to be hearing next month about the details of this, so I'm not going to get into that at this point, and all of the factors that go into the deep percolation that you are recommending.

But I am wondering, the reason that climate change has been isolated out is -- I assume is that it is the belief that -- by EPA that this is where the major uncertainties are in extending out to the period of radiological stability.

DR. KOTRA: That's correct. And the basis for that, as I understand it, is if you go back to the National Academy recommendations there were specific features, events, and processes that were called out in those recommendations. And they were igneous, seismic, and climate variation.

So it was incumbent upon EPA, particularly given its burden to be consistent based on those findings and recommendations, to address them. They specified the limitation rather -- in a straightforward manner for both igneous and seismic as to what the limitation would be, and that was limited to the analysis of the effects of igneous and seismic to the effects on the waste packages that would result in releases.

They felt that it was important that NRC specify the best treatment of climate variation, which we have proposed in our -- and there was also a recommendation that while generalized corrosion may be less of an influence during the first 10,000 years, it might dominate in this very long period after 10,000 years. And so they included general corrosion among those specific features, events, and processes that need to be considered.

MEMBER HINZE: One of your bullets here is that the proposed revisions that you specify -- that DOE must use in performance assessments after 10,000 years. Does your technical staff -- has your technical staff found any areas in which there may be large uncertainties that must be taken into account, for example, in the seismic activity in that post 10,000 years that would suggest that you should give some advice to DOE on how to specify their performance assessment criteria?

DR. KOTRA: Well, I'll let Tim get to that. But before I do, I would just say that it's important to keep in mind that that statement up front that EPA makes about the suitability of the performance assessment for the first 10,000 years as being a suitable starting point is based upon the fact that the consideration of features, events, and processes are not limited in setting up that original performance assessment.

We're not limited to just the last 10,000 years at Yucca Mountain. Careful consideration went into the selection of those features, events, and processes, based upon a thorough understanding of the site over the quaternary.

So a lot of the uncertainties that you're talking about have already been taken -- would have already been taken into effect in identifying. That's not to say that there aren't new and more significant effects over that longer timeframe that might emerge as important.

But, Tim, how do you -- do we have any additional guidance that we're going to give to the Department for treating seismic in the 10,000 to one million period that we haven't already given them for the first 10,000?

MR. McCARTIN: Not that I'm aware of. I think you characterize it very well. There may be -- once again, it may be another subtlety here that may not be fully appreciated. But, say, in the first 10,000 years, we have -- the probability cutoff is $10^{-8}$. So say a $10^{-6}$, $10^{-5}$ seismic event is considered in the first 10,000 years analysis, the uncertainties associated with estimating that $10^{-5}$, $10^{-6}$ earthquake are in that analysis, it will be in the analysis beyond because you're using that 10,000 year assessment.

And so a $10^{-5}$ earthquake and the uncertainties with it is included in the million year analysis. One might argue that you may not see it very often in the first 10,000 years, but you go out to a million years, the probability in the number of $10^{-5}$ events, you will see them more often, and that is included in the analysis.

But you have a basis for estimating its probability and its magnitude in the first 10,000 years. You're just extending that. And as Janet indicated, there was certainly a lot of long-term information well beyond 10,000 years that was used to determine what that $10^{-5}$ seismic event would look like.

So there is -- these kinds of things are still being -- the evolution of the site still has these low probability events, and one would argue that certainly you would expect to see them more often in a million year analysis than you would in a 10,000 year analysis, and that should show up in the calculation.

MEMBER HINZE: There's no evidence in the technical -- from the work that your technical staff has done on this that the probabilities of the $10^{-5}$, for example, will be changing and leading to large uncertainties in that post-10,000 year period.

MR. McCARTIN: Well, that's where I think we would go with -- the period of geologic stability would suggest that indeed the kind of information you have is -- the system is geologically stable. That there wouldn't be any, certainly, radical changes to the prediction of geologic events.

MEMBER HINZE: Thank you.

A final question, Janet, if I might. Referring again to the performance assessment, have you -- has the NRC done any exercising of their codes out to a million years to try to ascertain if there are problems that might lead to some guidance to the DOE for that post-10,000 year period?

DR. KOTRA: I believe the short answer to your question is yes. But, again, Tim, you have more experience in that area than I. Would you --

MR. McCARTIN: Certainly we are in the process of enhancing our code to account for the longer term. And that's both trying to get a better handle on what nuclides need to be included. There might be some plutoniums that we didn't have in our previous calculation that we want to add in.

And there is certainly -- just the hardest thing we're probably working on is just the efficiency. It's one thing to do a 10,000 year analysis. Going a million years is quite a bit longer, and we're looking at ways to make the code a little faster to get the results. But to date, I don't know if there's anything truly dramatic that we're doing other than possibly, you know -- and I wish I could remember.

But one of -- we've added a plutonium into the data set, and I -- I, for the life of me, can't remember, is it 238 or 239. But I --

CHAIRMAN RYAN: 238 is in 84 years, so probably --

(Laughter.)

MR. McCARTIN: Yes. Then it's not that one. But that's probably the biggest thing we're looking at -- what's the impact of adding that additional plutonium in there. And certainly the newer dosimetry is -- does make a difference. It increases the dose conversion factors for some nuclides, decreases it for others, and so -

CHAIRMAN RYAN: Tim, one thing that would I think help the committee in looking ahead to December a bit is if we could get some insights from what you've done on inventory from 10,000 to a million. I think that would be very helpful to keep us focused on -- you know, from a radionuclide inventory standpoint what the players are in your mind, just -- and, again, not from any other aspect, but just the inventory from 10,000 to a million years.

That might be something helpful for us to hear and discuss.

MR. McCARTIN: Yes.

CHAIRMAN RYAN: And then, I think if we could learn from you all as well on the insights that you've got from the dosimetry aspects, those might be two things if you're ready to talk about that would be -- that would be great . That would be real helpful to us.

MR. McCARTIN: Yes. That's a good heads up, and we can have something on that.

CHAIRMAN RYAN: Right. The third one, as I recall from previous meetings over the last several years, you did some ranking, you know, on the basis of inventory and on the basis of other key parameters, and so forth. I'm going to guess that's a little further out down the line.

MR. McCARTIN: Yes. Yes, we haven't gone quite that far, but it --

CHAIRMAN RYAN: But aiming at something along those lines, again, in that context --

MR. McCARTIN: Sure, yes.

CHAIRMAN RYAN: -- would be real helpful. That was very, very helpful to our insights. And, again, if we could think ahead to that, that would be terrific.

MR. McCARTIN: Yes. I mean, there are certainly some variations that are very -- that are interesting, that we, you know, just didn't have. And like I say, plutonium I think -- like, say, the inventory, in terms of fraction of the inventory, it probably peaks around 300,000 years for all the plutoniums considered, and then -- but then starts fading away and other things come in, say, at the 5-, 600,000 year. So, yes, we can -- we have information on that.

CHAIRMAN RYAN: And as you did on your previous analysis for 10,000 years, that -- those insights into the inventory I think set the stage for what should be the risk-significant kinds of things to think about from that point on. So I think that would be helpful.

I'm sorry, Bill, I interrupted you.

MEMBER HINZE: That's fine. Can I ask --

CHAIRMAN RYAN: Please.

MEMBER HINZE: -- take time for one more question. I've got to ask you one climate change question, and I'll try to leave the rest until next month.

But I'm wondering if, in the consideration of the deep percolation, that you have taken into account the work that's been going on now for half a decade by the U.S. Geological Survey on the deposition of calcite and opal on the fracture openings in the tufts, which would indicate that -- dating of those would indicate that there has been a rather consistent depercolation through the repository types of -- through the repository level, even during the monsoon period of the last glacial period.

And there is -- and yet you have come up with that it's -- that you have six times the deep percolation of the present as kind of the average. I'm wondering if that information has been taken into account, and the possible buffering of the tufts.

DR. KOTRA: We will be prepared to address that in a lot more detail in December, but let me say this. We know that roughly about four percent of the precipitation that lands on the surface of the mountain makes it to depth, roughly. That's a rough estimate. We know that in cooler and wetter climates, which we have evidence for at Yucca Mountain, that that can go up to as high as 20.

And so in a very general sense, there was an effort to make an estimate of a suitable range that would take into account, recognizing that we're not going to peg it at that high, extreme value, but allow the Department to sample over the range.

In addition, I would have to -- I'm not familiar with the particular USGS data that you're mentioning here. But there was a great deal of effort on our part, recognizing that there are some questions that have been raised about data from the USGS in that particular area. There was a great deal of care taken to make sure that the technical basis for our selection was reinforced by peer reviewed data from other sources.

Our hope and expectation is is that the USGS data that also corroborates this will be found to be robust as well, but those investigations are ongoing.

Tim, did you want to address that any further?

MR. McCARTIN: I think that's -- for today, that's a very good answer. I mean, it -- you know, there was -- you know, we put out a -- what we consider to be fairly simple. It's not a very complicated approach for this. And we're very interested, as in everything in our proposal, to see what public comment -- if people are aware of other information.

MEMBER HINZE: Thank you very much.

DR. KOTRA: You're welcome.

CHAIRMAN RYAN: Okay. Thank you. Allen?

VICE CHAIRMAN CROFF: Is there any place where the NRC's proposal to implement the EPA standard differs from what the EPA has proposed?

DR. KOTRA: I would say no. I would say that in that -- in those areas where the EPA specifically directed NRC to do a piece of it, which was the treatment of climate variation, we went beyond what was proposed by the EPA.

In the case of the current dosimetry, EPA's standard only reaches calculations of the public. Because our responsibility extends to protection of the workers, we went beyond the EPA proposal in extending that philosophy to the worker dose calculations as well.

But in terms of any other area, no, there has been no -- we -- our job is to implement the EPA standard.

VICE CHAIRMAN CROFF: Okay. And with regard to determining whether the dose limit is met, the 350 millirem per year, my understanding is it's -- that DOE has to -- there has to be a reasonable expectation that DOE will meet the dose limit.

Given that it's specified that you have to -- that a median has to be used, what does "reasonable expectation" mean in that context? I mean, a median is sort of mathematically defined. And if they calculate a number, you know, it's less than, greater than, or equal to. End of story.

So how does the judgment associated with reasonable expectation get implemented?

DR. KOTRA: Well, that's true in making any regulatory determination. I mean, you could just say, is it, you know, above the line, is it below the line, is it at the time. But I think that it's incumbent upon a conscientious regulator to look very, very hard at the technical basis underlying the approach to calculating those estimates, the models that are used, the robustness of the data that supports them, the adequacy of the peer reviewed literature that supports the selection of the models, etcetera.

And that's the basis, as it has always been, in NRC regulatory decision-making to reach some level of either reasonable assurance or reasonable expectation that a standard has been met. So it's not just looking at the value, as you indicated, but it goes far deeper than that.

VICE CHAIRMAN CROFF: Okay. Thanks.

CHAIRMAN RYAN: Ruth?

MEMBER WEINER: Since Dr. Hinze asked some of my questions, I don't have so many left. But let me ask you maybe a difficult question. This is a draft regulation that EPA has put out for public comment. Suppose for a moment the public comment is such that EPA either changes its regulation, changes its draft completely in some fundamental way, or says we're going to go back to Congress -- in other words, does something to radically and greatly change this draft. Where does that leave you?

DR. KOTRA: Right where we would expect to be. I would be surprised that they wouldn't make some changes. If those changes are relatively minor, it is our obligation to implement the final EPA standards. If there is a radical departure from what has been proposed, then the Commission would have to consider reproposal.

And part of -- you know, depending upon how radical, you mentioned going back to Congress. That could change the entire framework, which might also touch our responsibility to implement EPA standards. But assuming that that stays in place, if the approach is radically different than the basis for our proposal here, then I think the Commission would have to take under consideration the possibility of reproposal, or what other alternatives might be available.

But our expectation is certainly that it's a proposal. Our obligation is to be consistent with a final. But it is important that we went out with the proposal when we did to make the broader public aware of the fact that we are under this obligation, and this is what our rules would look like if this proposal were to be enacted.

And so we will -- we will respond accordingly once we see what the final standard is.

MEMBER WEINER: Responding to some of the public informal comments I have heard, I would say -- I would encourage you to make that last observation very clear in your public pronouncements. That you are exercising your responsibility under the Act to react in a timely fashion, to come up in a timely fashion with a regulation that is consistent, but that if there were to be a different or a substantial change in the regulation, you would, of course, accommodate that as well. I think that's -- that's an extremely important thing to get across to the public.

DR. KOTRA: I appreciate that observation, and we'll take that to heart.

MEMBER WEINER: Now, how do -- you're going to get the same questions EPA got, whether -- you know, whether this is within the law or not. How would you respond to the step function question? Fifteen millirem per year is what we had to do for the first 10,000 years, but after that it's okay to go to 350 millirem per year, and, in fact, I heard statements that said 10,000 years and one day we can go -- raise the standard by a factor of 20.

DR. KOTRA: Well, we made it very clear in our proposal that our proposal addressed the implementation of the risk management judgment that EPA was tasked to make by the Congress. And we would direct comments on the nature of that judgment to EPA.

To the extent that those comments touch on our ability to implement, then we would clearly have to address them thoroughly in our response to comments on our rule. But the -- as I indicated, we have not been made aware of any desire on the part of the Commission to comment directly on EPA's judgment.

And so in terms of responding to comments on this rule, I think we would say that it's outside the scope.

MEMBER WEINER: It's just outside the

scope of your --

DR. KOTRA: Yes.

MEMBER WEINER: -- comment.

DR. KOTRA: Tim, did you want to add anything on that?

MR. McCARTIN: Yes. I think that's a fair statement. But there is one additional thought that I think, if indeed, just with the previous standard, that had no measure after 10,000 years, if there was a dose that year 10,001 that was much larger than 15 millirem, we would certainly -- the Commission would look at the assumptions in the performance assessment that resulted in that dose being just beyond there and making sure that, indeed, there was a basis for saying that did not occur in the first 10,000 years.

So, I mean, there is a -- a -- I mean, I appreciate the idea the standard does go up. But, you know, there are uncertainties, and we would look at the basis for -- as we would have previously, that if the dose went beyond 15 just after 10,000 years, what in the performance assessment is causing that to occur, and why? And so --

DR. KOTRA: I've been with this program long enough to remember when there was a time when we thought we would have to implement 191. And that also had a step function associated with it, and we were prepared to implement that. And we can implement the standard as well.

MEMBER WEINER: Again, I would encourage you to make these things clear in any public statement, because this -- one of the things I took away from sitting through the hearings, and Tim may have also -- he sat through the same hearings -- was that these points are not clear to the general public. They are very -- they are quite confusing, as is the mean versus median question.

And, again, you are simply implementing, but how would you respond to that? Why go to the median instead of the mean?

DR. KOTRA: Again, as long as we believe that the proposal is fundamentally protective, which considering it adds additional criteria on top of a standard that we already believe was sufficient protective, meaning the existing standard, we are not prepared to say that that is insufficiently protective.

But we will pay very close attention, and we've been directed by the Commission to pay very close attention to the public comments that EPA receives on both the level of protection and the statistical measure used to evaluate it. and we will be prepared to implement that final judgment of EPA's.

MEMBER WEINER: Okay. Thank you.

CHAIRMAN RYAN: Clarke?

MEMBER CLARKE: Most of my questions have been answered as well. Sometime ago we heard an excellent presentation on waste isolation in the geosphere and risk insights, and I just want to second Dr. Ryan's suggestion that you update the inventories and take a look at it that way. I think that would be very informative for us.

CHAIRMAN RYAN: Any other questions from staff? John Flack.

MR. FLACK: Just for a tidbit of information, John and I have --

CHAIRMAN RYAN: Let me remind everybody that uses a microphone, would you tell us who you are and who you're with.

MR. FLACK: Okay.

CHAIRMAN RYAN: And pull the microphone close to you. And if you haven't already, please, I'd ask that you sign in on the sign-in sheets for those that haven't.

MR. FLACK: Sure. I'm John Flack with the ACNW staff. I was just saying that John and I were both fellows at the same time, many moons ago, at the ACRS. So nice to see you again.

I just have a question. It goes back to the mean versus the median. Does the staff intend to -- since it doesn't take any additional effort, really, to calculate the mean and compare it to the median, does the staff intend to compare these two numbers, and if there's a large discrepancy between -- or I shouldn't say -- I should say difference between the two, that they would somehow try or attempt to reconcile those differences?

DR. KOTRA: I think that we routinely calculate means now. I expect that we would continue to do that, and it would provide the basis for any recommendation the staff would make in a safety evaluation report on reasonable expectation. Certainly, that is information that we -- we will acquire and calculate.

The judgment on the basis for the safety standard, of course, is EPA's to make. And as I indicated, we will implement that. But in terms of exercising our own independent capability to evaluate DOE's performance assessment, we would, of course, use any information available to us, including those calculations.

MR. FLACK: Can I ask one other question?

CHAIRMAN RYAN: Sure.

MR. FLACK: Is there any difference in the calculation with going from 10,000 to a million years? In other words, are there conservatives -- conservatisms in the first 10,000 years that would need to be removed and calculated out to a million years because they wouldn't be tolerated in that kind of additional timeframe?

DR. KOTRA: No. I think EPA has made it very clear, and we agree, that the basis for the original calculation of 10,000 years is a suitable basis for projection, with some caveats with regard to treatment of uncertainties. And they have identified those areas -- igneous, seismic, climate variation, and general corrosion -- that need to be explicitly taken into account.

I think it goes the other way, and that is that for the original 10,000 years general corrosion is really not an issue. But when you go out to a million years, then general corrosion is extremely important, and it has to be treated. You don't want a situation where they would not examine that process.

So, therefore, EPA has included that and told us that we have to specifically include it when we evaluate DOE's performance assessments. But recognize that the basis for that 10,000-year calculation took into account a much more global understanding of the site, and events that have taken place at the site for several million years before present.

So it's not like this is a whole new area. We are extending calculations based upon as much knowledge of the site as has been gathered.

MR. FLACK: So you would consider both calculations as being realistic.

DR. KOTRA: I didn't say that.

(Laughter.)

I think that it is important to keep in mind that there are huge uncertainties with both estimates. And it's important to understand what -- the limit of the knowledge you have and where it can take you and where it can't.

The National Academy provided guidance on that, and it's very important that the -- and I think they spoke very eloquently about that. But their view was that for the period of geologic stability, where our understanding of processes are sufficient to be governed by the same general mechanisms, the things that caused climate variation in the past are the same things that are going to cause climate variation in the future.

There's not going to be some new phenomenon that's going to emerge that's going to cause some dramatically different approach. Those types of assumptions are being played out over a longer compliance period, but it is --

MR. FLACK: Same assumption.

DR. KOTRA: Right. And EPA has specifically stated in its proposal that the basis for making that 10,000-year performance assessment is a sound starting point for extending that calculation.

Did I answer your question?

MR. FLACK: Yes.

CHAIRMAN RYAN: Professor Hinze?

MEMBER HINZE: Can I throw out a question here? And this goes to I guess both Ruth and Dr. Kotra. Ruth, in your fourth slide, you define the major points, and one of the points that was made over and over again is that the choice of the median greatly -- and I emphasize that adjective -- greatly increases the allowed upper limit from the repository.

What does that "greatly" mean? And I guess this gets back to what John was talking about. Do we have any sense here of what the difference is between the mean and the median?

MEMBER WEINER: Well, I can only quote what people said. The median is the middle value, so, in theory, it could go as high as you want. The sort of numbers that were bandied about -- and I'll ask Tim what his recollection was -- was something like 1,050 millirem per year, one rem per year, numbers of that -- of that order of magnitude.

Is that your recollection, too, Tim?

MR. McCARTIN: Yes. Numbers like that were used. But what assumptions that were used to get to there --

MEMBER WEINER: We have no idea.

MR. McCARTIN: -- was unclear.

MEMBER WEINER: Yes. There was no explanation of where that number or any other number came from. But, of course, the crux of the objection was that in theory you could have a very -- a number as high as you wanted as long as you looked at the middle of the range.

DR. KOTRA: And I think that's the important point, in theory. I am no statistician, but my understanding is is that the mean and the median are fundamentally different measures of statistical tendency. And that, in principle, there is -- the median places no upper bound --

MEMBER WEINER: That's correct.

DR. KOTRA: -- whereas the mean would be much more sensitive to extreme outliers at the high end. That being said, at least my understanding of our preliminary calculations is that it's not making that dramatic a difference. But, again, until the performance assessments are completed, and we are able to independently verify them or dispute them, we can't say with certainty how big a difference that's going to be.

But as always, the mean would be higher than the --

CHAIRMAN RYAN: Ruth, let me ask -- I think this would be a topic as well for -- if it's a right topic for December that we'd like to hear a little bit more about. I mean, obviously, you can think about lots of statistics, the mean being one and, you know, other parameters of, you know, geometric standard deviation, a log normal case, or whatever you want to think about. There's lots of ways to think about in gaining insight from the use of statistics.

So I think if we could maybe look ahead to a presentation addressing some of that aspect of it from your standpoint of how you're entering the analysis, or what your thinking is as you enter it, that might be helpful. Is that a reasonable topic for December, or is that pushing it?

MR. McCARTIN: Well, we certainly can use some past results --

CHAIRMAN RYAN: Okay.

MR. McCARTIN: -- to look at the -- how the distribution of doses varies. Both, you know, DOE's FEIS results are available, you know -- you know, in terms of the newer dosimetry, and things might change some, but -- but certainly looking at the -- at what does the distribution look like? And I think --

CHAIRMAN RYAN: And real specifically, what does the mean versus the median create in terms of statistical inference?

MR. McCARTIN: Yes. I mean, in general, I mean, I'll say that for the 10,000-year analysis, generally the mean was a very high percentile. But that, in part, was dominated by the lifetime of the waste package. That depending on how the waste package performed, and if you had some -- a few small realizations that had waste -- more waste package failures, it dominated the 10,000-year dose.

In the million-year calculation --

CHAIRMAN RYAN: And you could think about weighted means and things of that sort.

MR. McCARTIN: Well, it's a different situation. What we've seen in DOE's results certainly, and ours, that the -- the mean is a much lower percentile in the beyond 10,000 year than it was for the 10,000-year analysis.

CHAIRMAN RYAN: Thanks.

MR. McCARTIN: But we can certainly get into more detail.

MEMBER WEINER: Can I just ask a clarifying question of both of you? Are you saying that by doing the performance assessments out to a million years you will identify some kind of maximum -- some kind of upper limit dose? That's -- you expect that to come out of the performance assessments, or am I misunderstanding?

DR. KOTRA: Well, that is the criteria that EPA has established as the basis for comparison to the 350 millirem limit, yes. But what that will be when the Department of Energy conducts that, and then we independently evaluate it, I'm not prepared to say.

MEMBER WEINER: No. I'm not asking. I'm just asking about the method.

DR. KOTRA: Right.

MEMBER WEINER: Thank you.

CHAIRMAN RYAN: Any other questions? Yes, Mike Scott.

MR. SCOTT: Mike Scott, ACNW staff. I just wanted to ask a clarification question of Tim. Regarding the statement about the difference between the mean and the median at a million versus 10,000 years, is that because -- is that a different conclusion because essentially all of the waste packages have failed out towards a million years? And, therefore, there aren't any, you know, small number of realizations that cause the mean to be much higher?

MR. McCARTIN: I won't say that all of the waste packages are failed, because I'd have to go back and look. But certainly the majority of waste packages are failed after 10,000 years. And prior to 10,000 years most analyses have a small subset of waste packages failed.

And so that is -- in looking at the results, that's why, you know, it would appear that the mean was dominated by the cases, and not surprisingly, where the waste packages had some percentage of failures, whereas you just don't have that in the long term. And, plus, you have neptunium, which is a very long, protracted release. In 10,000 years, you have the spiky iodine technetium releases. So the combination I think.

But primarily waste package failure, yes. And as the Academy said in their report, eventually you get to some point where the waste packages are failed. And that's sort of -- that's what you see in the after 10,000 versus the before.

MR. SCOTT: Thank you.

MEMBER HINZE: Can I ask one more question, if I might, please? Do we have time?

CHAIRMAN RYAN: Okay.

MEMBER HINZE: Briefly, in the current 63, we have this rather arbitrary 10,000-year cutoff. But the recommendation is that the performance assessment extend beyond the 10,000-year period. Now we put that up to a million years, and we call that the time of geological stability.

I would suggest that that one million years -- tying one million years to the period of geological stability is a very iffy -- is a very iffy concern that the time period of stability -- geological stability may extend much beyond the million years.

My question is: are you going to recommend to the DOE that they look beyond that 10,000-year period in the performance assessment, because this period of geological stability may extend beyond that?

DR. KOTRA: Well, they are definitely planning to look beyond 10,000 years. They're going to --

MEMBER HINZE: No. Look beyond the million.

DR. KOTRA: No.

MEMBER HINZE: No.

DR. KOTRA: Not as far as I'm aware.

Tim, is that correct?

MR. McCARTIN: No. It's not in the standard, and so that -- that part -- the part you are referring to in 63 was also part of the standard that we implemented in looking beyond 10,000 years. So --

DR. KOTRA: That was for purposes of inclusion in the EIS.

MR. McCARTIN: Yes.

DR. KOTRA: According to EPA. And so we included that, because we were implementing the then extant EPA standard which required that look beyond 10,000 years for purposes of inclusion in the EIS. We do not intend to go beyond what EPA has recommended.

MEMBER HINZE: So you're not going to worry about the one-million-and-one-year peak event?

DR. KOTRA: No.

CHAIRMAN RYAN: Okay. We're at our scheduled break period. So I think we'll recess here until 10:15, and we'll resume with our presentations for stakeholders.

Thank you, all.

(Whereupon, the proceedings in the foregoing matter went off the record at 9:57 a.m. and went back on the record at 10:16 a.m.)

CHAIRMAN RYAN: On the record. All right. Over the course of the next session, before the lunch break and after the lunch break, we'll be hearing from four stakeholders. The names of these four folks are Dr. Dade Moeller, Dr. Thomas Tenforde, Dr. John Kessler and Mr. Martin Malsch. I'll introduce them each and their affiliations at the time they speak.

It's my pleasure to welcome Dr. Dade Moeller who is Professor Emeritus from Harvard University and Chairman of the Board of Dade Moeller and Associates. Dade also was Chairman of the Advisory Committee on Reactor Safeguards and the first

Chairman of the Advisory Committee on Nuclear Waste and served in that capacity through 1996.

DR. MOELLER: '93.

CHAIRMAN RYAN: '93, I'm sorry. So without further ado, let me ask Dade to give us his presentation on the EPA proposed Yucca Mountain standards. Welcome, Dade. Welcome back.

DR. MOELLER: Thank you, Dr. Ryan. It certainly a pleasure to be here and I have listened with deep interest to what has taken place up to this point.

What I'm going to do is look at the EPA's proposed standards and I'm going to review, evaluate and provide you an independent assessment. In other words, if someone else did those same comparisons of the Amargosa Valley to the State of Colorado, what sort of an estimate might they have come out with? I hope to provide you as I move along with details of what we did and in every case, we cite exactly the reference or the source of particular number. Not only do we cite the source, but we tell you the page number and the paragraph so that you can find it equally.

If you disagree with what I present and you can provide a better approach or refine on what we have done, that's fine. This is a work in progress and we do not claim that our word is the final word. And we certainly do not claim that we have thought of everything.

But the underlying factor of all of our work is to apply the principles of good science. I've listened to the discussion this morning and I've heard very little about the principles of good science. I've heard about estimates and so forth but to repeat, that was our approach.

Now when I say "we" this is a presentation that was financed totally by Dade Moeller and Associates. We wanted to provide an independent assessment and had we gone to DOE or EPA or the NRC and asked for a contract to do this, we would have been beholding in a sense to the contractor or the agency that provided the funds and we wanted to state categorically that this is our own assessment and no one has influenced what we did.

Now I almost ruined that this morning as coming into the building, I thought I'll get through that gate in a real timely manner and I gave them my DOE badge. I thought "Good grief. What a mistake. Now I'm biased on favoring DOE." But thanks to the guard. He said, "What's this thing?" And I said, "A

DOE badge." He said, "That's worthless. That doesn't mean anything here." So I'm coming to you totally unbiased with a good science presentation.

If you read back on the proposed standards, the objective of our work is to provide scientific data for the establishment of a dose rate, again, the same as you've heard from $10^4$ to $10^6$ years after repository closure. Now the way it's stated in EPA standards is to ensure that releases from Yucca Mountain will not cause exposures to the RMEI, the reasonably maximally exposure individual, which is the average resident of Amargosa Valley to a dose that will exceed natural background levels with which other populations live routinely. And again, in line with what I just told you, that's in EPA 2005 page blah, blah, middle column. Okay. Let's move on.

Now we are using as one of our references is the EPA proposed rule that you've already heard and where it's accessible and so forth. So you've heard that discussion.

What is the basis of the EPA's proposed rule? What was the basis of using variation in natural background? If you search out the literature on this, particularly the international literature, you will find that this is in accord with a long-standing recommendation of the ICRP, the International Commission on Radiological Protection. When you look at it, what they say, now this is from their 2005 Proposed Standards, they consider that the annual "effective dose," please note those two words "effective dose," not the dose from radon or the dose from cosmic or anything, it's a combination and it's the effective dose from natural radiation sources and its variation from place to place is of relevance in deciding the levels of maximum constraints that it now recommends.

It's unfortunate in my opinion that EPA didn't cite something like this in their proposed rule. Now here is the reference for it. Let's go on. You can have those in the handout. I have 107 slides. So I'm going to be moving along. What I'm trying to do though in essence is present not only our findings but a tutorial on how if you apply good science, you would have estimated the natural background dose rate to the people of Amargosa Valley and whatever other group you want to compare them to.

Now the ICRP has also stated in its 1991 Publication 60 the following. They say although natural background may not be welcome the variations from place to place (excluding the large variations in the dose from radon in dwellings can hardly be called unacceptable). Now they do mention there variations in radon and of course, if you selected as your comparison group some of the people that live on the Reading Prong where the radon concentrations in the homes are very high or if you compared it to a population residing on the Colorado Plateau where it's high uranium content and so forth, you could biased the data.

So we have tried to avoid that. We have select comparable groups to compare Amargosa Valley to. So we'll be doing that. That's the reference for that information.

Now for purpose of EPA assessment, this is the way they define natural background. They said external exposures from cosmic and terrestrial sources and internal exposures to naturally occurring radon. That is a rather nebulous statement because external exposures from cosmic, outdoors or indoors, terrestrial doses, outdoors or indoors, radon doses, outdoors or indoors, that's not clarified. So go ahead. The next one.

Serving as a basis for the data that EPA used in its proposed rule is this report that was prepared by John Mauro and Nicole Briggs of Sandy

Cohen and Associates. You'll notice as I go along I will find fault with this report. However, I always try to put myself in the other person's shoes and I don't know how long they had to prepare the report. I'm sure they were under heavy pressure because EPA wanted to get out its proposed rule. So they undoubtedly cut corners and so forth to get it out. But we'll go on now and see some other comments.

Their report, the Mauro and Briggs report, covers the Indoor Cosmic and Terrestrial Radiation doses and the Indoor Radon and the radon concentrations as you see there were based on EPA's National Data Bank. There's no discussion of outdoor cosmic or outdoor terrestrial or outdoor radon. Furthermore, according to the calculations that they used as best I can decipher what they did, they assumed the person remains indoors 100 percent of the time. You'll see later on we generally for our standard calculations you adopt an indoor occupancy factor of 80 percent and an outdoor occupancy factor of 20 percent.

What are the omissions? The outdoor dose rates from cosmic and terrestrial. The outdoor dose rates from radon. The dose rates from ingested radionuclides. Your primordial radionuclides in the cosmogenic. The primordial are the decay products of uranium and thorium in the soil. The cosmogenics are what the cosmic rays and so forth produce in the atmosphere, one radionuclide being carbon-14. Now of that is there.

The dose rates from building materials. If you live inside of a concrete block or a brick house, you receive a certain dose from external sources, namely the consumer products that were used in building your home.

The dose rates from airline travel. Today for cosmic ray dose rate estimates you add in the amount of air travel. This is easier to do nationwide but the NCRP adds in the added dose from cosmic rays due to such a high percentage of our population who travel by air. I know one or two of you here who fly once and a while.

It's affected by the influence from housing, the type of housing. You'll see that when I cover and discuss the Amargosa Valley or when I talk about another site. I'm getting ahead but I'll be calculating for you the dose rates in Leadville, Colorado. Leadville about 30 to 40 percent of the homes are brick or concrete block.

We took into account, and because it was omitted and because we knew it belonged there, the influence of snow on the roofs on homes and on the ground in terms of external cosmic and terrestrial dose rates. If you are going to do a scientific approach, if you're going to apply the principles of good science, you have to consider these things.

Then we also thought about it but we did not, well, we did and we didn't, you'll see when I get to it, the influence of snow cover on the ground in terms of radon dose rates.

Although it is not clear, I've already said this, EPA apparently assumed 100 percent indoor occupancy and this would yield estimates that they're not quite 20 percent higher because outdoors you get some radon dose. So I probably should have said 15 to 20 percent too high.

All right. Here's the number one important observation. There will probably, I hope, be ten important observations in what I have to say. No. 1, the dose rates from radon and its decay products in the Sandy Cohen's report were based on a conversion factor you might call it of 9.6 millisieverts per working level month. The NCRP Scientific Committee 85 whose report I talked to Dr. Tenforde this morning and he tells me it will be out perhaps between six and 12 months from now in that report they recommend a ratio of 4.8 millisieverts per working level month.

Now you could say first of all that's half the dose. 4.8 is half of 9.6. Why did this come about? It came about because the experts, the scientific group, for example, Naomi Harley, one of the world's experts on radon, chaired NCRP Scientific Committee 85, those people reached the conclusion that the radiation waiting factor for radon decay products in the bronchial epithelium of the lung should be 10 not 20.

Generally, those of you who are health physicists, you know that when we're dealing with the biological effects of alpha radiation, internally deposited alpha-emitting radionuclides, we apply a tissue waiting factor of 20. For the unique characteristics of the manner in which the radon decay products deposit in the bronchial epithelium, they have concluded that 10 is the correct radiation waiting factor. Now let's go ahead.

This is not something brand new. If you look in UNSCEAR, their scientific report of the year 2000 and let me pause and say that is the best bible, that is the best guideline you will ever find in terms of estimating dose rates from natural background. It is a superb report. It includes, of course, the doses from flying, airline travel and so forth. It is just a super report.

In that report issued in the year 2000, they said that the dose rate from radon decay products deposited in the bronchial epithelium is 9 nanosieverts per Becquerel hours per cubic meter. Now I should have said it back on the previous slide. Flip back please.

Here the working level month is an expression of an integrated dose. You have been exposed to a concentration of some many working levels for so many months. The product of the two is an integrated dose. The working level month, the working level concept, was developed back when the U.S. Public Health Service was first doing the epidemiologic studies of the uranium miners right after World War II and during those studies, they needed some way of expressing the dose rates from radon decay products and Duncan Holaday who shepherd that program the entire time came up with this concept which had lived on today.

Here 9 nanosieverts per Becquerel hour per cubic meter is the same thing said in a different slightly way of a working level month. You are exposed to so many Becquerels per cubic meter for so many hours. That's a product. A concentration times the time you were exposed to it, an integral of the two and therefore it is the same as a working level month.

Now because UNSCEAR use slightly different lung model and because they are converting from picocuries to Becquerels and from millirem to sieverts and so forth, there were certain little factors, differences, in the two. To make it exactly equivalent to 4.8 working level months, we upped the 9 to 9.6. There was a seven percent difference and since we were doing calculated using both sets of dose conversion factors, we upped it to 9.6 simply so regardless of what approach we used we got the same answer.

Again, you may say you shouldn't have done that. Fine if you don't think we should have. I'm telling you what we did. You can go back and do it your way. The reference. Go on please.

The original U.S. EPA plan, you heard it earlier this morning which set a standard that would represent a level of incremental exposure again so that RMEI could be comparable to the total natural radiation exposures incurred now by current residents of well populated areas. Go ahead.

They also stated that although they wanted to do dose estimates for Amargosa Valley, the data were not available and therefore they did not do it. So what they did was they took the estimate of the average dose to the average member of the public in the State of Nevada and they adjusted that to match what they assumed to be the dose rate to the residents of the Amargosa Valley.

How did they do that? The estimated average for the State of Nevada was 2.22 millisieverts per year. However, two-thirds of the population of the State of Nevada resides in the area around Las Vegas or Clark County and that is an area of relatively low radon concentrations compared to the Amargosa Valley, to Nye County, which has Yucca Mountain in it and the Amargosa Valley. So they modified the 2.22 taking into account the differences in Clark County and Nye County and they came up with their 3.5 millisievert difference and so forth between what they call the State of Nevada meaning Amargosa Valley and the State of Colorado.

So just keep that in mind. Often times, even when I'll say State of Nevada, I'm really meaning the Amargosa Valley if I'm quoting EPA's numbers.

Now what did we do? We tried to apply the scientific approach. We indicate clearly the assumptions we make. We cite the detail references. When options are available, we were very careful to always go to direct measurements. That's your best sources of data and cross check to insure compatibility with other people's measurements or measurements made close by and so forth. We tried again good science every step of the way.

We exercised care and we call this later conservatisms and that's probably a misuse of the term. But what we tried to do was to estimate the dose rates for the higher natural background levels. We tried not to overestimate those and we tried not to underestimate the dose for the Amargosa Valley to make that difference bigger than it should be.

We tried to be conservative. In other words, if there was a choice, we would underestimate the high area and if there was a choice on the low area we would overestimate it there so that difference wouldn't be something that you could say, "Good grief. No wonder you got the differences you did."

A search of the literature after EPA said the data for Amargosa Valley are not available, a search of the literature showed that there was quite a bit of data for the Amargosa Valley and then the same proved true for Leadville, Colorado. And we thought we're comparing one community. Why not compare it to another community that has a higher dose rate and where people have lived for hundreds of years and so forth. So that was the approach that we took and the effective doses, we included all the sources of natural background.

Now the reference for Amargosa Valley that we used was Steve Maheras's. Now let me pause for a moment here. This is a bias but once I see a name and once I see data, I say first of all, is he a health physicist. Well, he is. No. 2, is he board certified? Yes, he is. Those are the things that count. If you want good data, you go to a board certified health physicist.

Leadville met the requirements of the ICRP and has a relatively high cosmic radiation dose rate. It's at 3200 meters altitude, 10,500 feet. I don't know how. They must have powerful lungs or something because I was stationed in Los Alamos for three years and it's only at 7,500 feet. But when you first get there, you pant for awhile. But you do get used to it.

It has a high terrestrial dose rate. It's interesting. Several references that we reviewed showed that the higher the altitude the higher the terrestrial dose rate. I think God made a mistake. If the terrestrial had gone down with altitude as the cosmic went up, we wouldn't have these differences. Of course, then EPA wouldn't have a good number. And it also has a relatively high but not excess indoor radon concentration. Of course, if it has high terrestrial, it's going to have some high radon in the homes.

The two communities, they're located in similar regions. The population of Leadville about 2,600. The Amargosa Valley 1,100, 1,200. Site specific data are available. Uncertainties are reduced. Let's run with it. Now we ran with it but we also, and I'll really go fast, did calculations for the State of Colorado, the average, and the average for the State of Nevada. We'll give you all of the comparisons when I'm finished.

Both indoor and outdoor dose rates were estimated. We used the occupancy factors I've already discussed and we included the dose rates for ingested radionuclide building materials and so forth.

The shielding factors. Now again, the

UNSCEAR report and the NCRP Report No. 94 is superb. Of course, it's the definitive other than adjustments and again Dr. Tenforde reminded me that they're doing a complete recalculation of the natural background dose to the U.S. population but that report has the same shielding factors and the same occupancy factors as the NCRP, in other words, endorses the same numbers that UNSCEAR uses. That's the bottom line.

Now the effective dose rates from ingested were included. I've said that. The site specific refinements were also incorporated. Now I'm going to discuss some of our site specific adjustments for Leadville and the Amargosa Valley. Let's go on.

Snow cover. UNSCEAR estimates that snow cover on the ground per centimeter of depth reduces the terrestrial dose rate by one percent. Now that's a very useful guide and we considered that. Snow cover also retards the releases of radon into the outdoor air.

I'm jumping ahead to Leadville. Fortunately, I had a lady contact, let me back up though. One of our employees lived in Leadville for three or four years. So he was able, he happened to be a man, to tell me a lot about the snow cover and he said that the winter begins in October and it doesn't end until the end of April, high up and cold and so forth. He told me the average depth of snow in Leadville is three to four feet for the winter months.

I was flying a couple weeks ago from Denver to Boston and a nice lady sat next to me and I don't usually chat but I did for a moment with her and I'm glad I did because she was chief librarian for the public library in the City of Denver. I said Leadville. She said we go up there all the time. We ski and we just love it. It's a wonderful community. I independently, I wanted an independent assessment basing this on the principles of good science and her name was Shirley Smith. It's an interesting name. I said depth of snow in Leadville. Three to four feet all through the winter. So she had the same number. I know it's good science and I'm rolling with it.

Now there's No. 1 important fact. Ninety-one percent of the people who live in the Amargosa Valley live in mobile homes. Factors that need to be considered are not only the structural implications of a mobile home in reducing cosmic rays coming in or terrestrial radiation coming underneath.

I think I skipped over that paragraph but the standard factor that you apply is you assume that the roof and the attic and all the rafters and everything in a typical everyday home reduces incoming cosmic radiation by 20 percent. You similarly assume that the floor structure and foundation of a home reduces the terrestrial coming in by 20 percent.

I said what about a mobile home. I don't know. So fortunately there were five boys in our family and No. 3, I'm No. 2, lives in Knoxville. He's No. 4. I'm sorry. That's not good science. No. 4 lives in Knoxville. So he said, "Dade." He always call me Dade. He said, "Dade, why don't I run down to Merryville where Clayton Holmes, the biggest builder of manufactured homes in the world, where they're located." So he checked it out for me. He got all of the details on the structure of a mobile home, the floor structure, the supports. If it's going to be rolled down the highway, it can't just be 2 X 4s. It has to be steel beams underneath that mobile home to keep it from sagging at each end. So we checked all of that out and the factors that needed to be considered is whether a mobile home supports the floor and the ceiling the same as a regular home.

There's our reference for the 91 percent. I wanted to point out. Even in North Carolina, eight percent where I'm from in North Carolina of the people live in mobile homes. The next slide.

Now furthermore, mobile homes must meet the code of the National Manufactured Home Construction and Safety Standards. So those were promulgated in 1974 and it's 31 years later. I assume, now we did not have time to check out when the mobile homes that the people in the Amargosa Valley, when they were made, but we assume if this has been in place for 30 years that the structural shielding for the ceiling and the floor reduce the cosmic and the terrestrial by 20 percent and as such, they provide the same shielding reduction factors for cosmic and terrestrial.

What about a mobile home? How many of you, maybe some of you live in a mobile home, have really studies or examined a mobile home? It's up a foot or more above the ground, usually on some sort of concrete blocks or something and they may have a dress curtain around but the air can blow through. And what is the concentration of radon inside a mobile home? It's roughly the same as the concentration outdoors because there's no pressure gradient to push radon in the homes.

So what is the indoor radon concentration in Amargosa Valley? It's not the average for the State of Nevada. It's not adjusted higher level to account for them being in Nye County. It's roughly equal to outdoors. Now that's the concentration, but what about the dose rate from the radon? Before I go on, I called Florida and the top radon person there. They're all in the back of the health physics membership book and I called North Carolina and they both said, "Sure, Dade. It's the same as outdoors." I thought I really want to the clincher. I'll call EPA. So I called and the same as outdoors. Okay.

Now confirm that in addition, the indoor radon, this is an important thing and I want to digress for a moment to go over with you what it is that determines the dose from radon. Radon doesn't give you much of a dose at all. It's a gas. You inhale it. You exhale it. The only dose you get is whatever decay takes place during that moment it's in your lungs and out. It's the radon decay products that cause the dose.

How does the dose relate to the concentration of radon? The dose relates to the concentration of radon in terms of the state of equilibrium of the decay products with the parent radon. Outdoors where the radon there's forever and the decay products are forming, being produced, you'd think maybe it's 100 percent equilibrium. No, outdoors is about 60, the maximum.

Roughly the equilibrium level outdoors is about 60 percent. Why? Because the wind is blowing the air around. If those decay products come near a leaf of a tree or grass or anything, they've plated out and once they've plated out they're no longer in the air. So outdoors it's about 60 percent.

Indoors, it's 40 percent. The average indoor is 40 percent. Now why is lower indoors? You're in a confined space. As the air moves around, it has all kind of chairs, tables, walls. It has a lot of things to interact with and plated out. And indeed it plates out and once it plated out, an alpha emitter is of no concern externally and you can say maybe a baby rubs his or her fingers and licks them but it's peanuts. It's a very low dose.

So indoors about 40 percent equilibrium. What does that mean? That means that even if the dose inside the homes, even if the radon concentration inside the homes, is the same as outdoors the dose will be 4.6 two-thirds of the dose outdoors breathing decay products with the same parent radon concentration.

Furthermore, I'm going to jump ahead, I called this just a work in progress and I don't think it will ever be finished, but I called Clayton Manufacturers. I don't prefer them but they were nice to talk to and they are a major manufacturer and I said, "What percent of your mobile homes" -- They said, "Hush. They're not mobile homes. They're manufactured homes." So you have to learn that. You don't say mobile when you're talking to them.

But they said the majority of the ones they sell today have ceiling fans. Okay. We did not include that in our assessment. But if the majority of the homes in Amargosa Valley have ceiling fans, this reduces the concentration of the decay produces by another factor of two, by 50 percent. So now you have one-half of two-thirds or a third. So if you're in a mobile home, excuse me, a manufactured home, and you have a ceiling fan, your dose through comparable concentration of radon compared to the outdoors will be one-third of that indoors.

I've already covered this if they have ceiling fans. Let's skip that. What's the reference on the fact the ceiling fans reduced the dose by a factor of two or more? This is the reference in 1983. You can look it up sometime. These people it doesn't show but they're all faculty coworkers of mine when I was at Harvard.

Now here's one that sort of gives me chuckles. You can say the people in Amargosa Valley may live in manufactured homes today but as they become more affluent, they build their own homes. In 10, 50, 100 years, they're all going to be living in conventional homes.

So how can you apply in your assessments the fact they now live in manufactured homes? Bless the EPA for that. They stated that RMEI is a person who lives in Amargosa Valley and has the same habits, food consumption and living style of current residents and they forbid you to project ahead and estimate they're going to change their ways. So you're stuck with it. Good science. I'm stuck with it and so that's what we use.

I'm going to be looking at all of these. Go ahead. We've already talked about it. I'm going to first do the Amargosa Valley. Then I'll do Leadville. Then Colorado and then Nevada. By the time we get to Colorado, you'll be tired and I will and we'll zip through those slides in a hurry. But it's all there, all the numbers are there, if you want to check them out.

According to Maheras, the dose rate outdoors from cosmic radiation in the Amargosa Valley is 0.39 millisieverts. Now all you have to factor in there is a two-tenths reduction due to the rafters and the ceiling steel beams and all in the mobile home. So you multiply it by ten-tenths. Excuse me. Here. I'm jumping ahead. I'm talking outdoors. I had already jumped to indoors. Talking about outdoors, outdoor occupancy factor is 20 percent of the time. So the prorated dose rate outdoors is the full dose times 20 percent outdoors or this.

Now let's do indoors. For indoors, you take the occupancy factor, well you first adjust it for structural shielding. It's unfortunate. The NCRP and ICRP only have two numbers, eight-tenths and two-tenths, and it applies to occupancy factor or structural shielding of anything. So if you first take this structural shielding, reduce the cosmic by 20 percent, multiply it by eight-tenths, you get the cosmic ray dose inside the home but their occupancy is eight-tenths 80 percent of the year. So the prorated dose indoors is 0.25. The next slide you add the two together and the average cosmic ray dose to the people in the Amargosa Valley is 033 millisieverts per year.

My tutor is saying I should be doing this. Amargosa Valley outdoors for terrestrial. It's 0.56 millisieverts per year. That's coming up from the ground. Twenty percent of the time you're outdoors gives you this much per year.

Now 80 percent that you're indoors, you first have to reduce it by 20 percent for shielding. That's this factor of eight. Then a factor of 80 percent for occupancy and you get the net result for the terrestrial dose rate. Very straightforward. The total Amargosa Valley is outdoor plus the indoor or 0.47. These are all based on measurements made in the Amargosa Valley and provided in Maheras's report.

Now outdoor concentration was 0.34 picocuries, this is for the radon, which is 12.6 Becquerels. Now this is the UNSCEAR. That's why I tell you. If you want to know about natural background, get a hold of that report and read it. Instead of saying an occupancy factor of two-tenths, they say two-tenths of a year, a year has 8,760 hours in it. One thousand, seven hundred and sixty you spend outdoors and 7,000, the other, you spend indoors.

So you just put the hours right in there, no eight-tenths, no two-tenths. You apply their equation. Now outdoors, 60 percent equilibrium times the hours times their factor and you get the outdoor dose rate from radon of 0.13 millisieverts per year.

Now that applies to the 91 percent who live in the mobile homes as well as the nine percent who live in conventional homes. However, in terms of indoor, we did them separately.

Indoors. The outdoor concentration is that. This is to do the indoor radon to the occupants of the Amargosa Valley and this would be here 12.6 and prorated for an occupancy factor of eight-tenths which is the 7,000 hours per year and an equilibrium factor indoors of four-tenths, we're not including the ceiling fans, times the 91 percent. That means for the 91 percent who live in the mobile homes, they're getting that many millisieverts per year.

Now for those in the other homes which I call conventional homes, the average radon concentration in homes in Nye County is this and this. Then we prorated again for only nine percent of the people live in those homes. Four percent equilibrium, nine percent who live in those homes times this concentration gave the annual radon dose to the nine percent who live in conventional homes and the next slide you add the two and 31, you get the total. Combine that with the outdoor and so the total cosmic ray dose, I mean total radon is 0.55 millisieverts per year.

Let's go on and look at ingested. Here we took the NCRP long established number of four-tenths of a millisievert per year due to radium, lead, all of the radionuclides in food and in water and so forth, but primarily in food. Then the cosmogenic threw in another one-hundredth of a millisievert, one millirem. So you get a total from ingested radionuclides of 41. Now the reference on that is that Report 94.

And now having done that, we said to ourselves we had data on the radium concentrations in the groundwater in the Amargosa Valley and we said if they have relatively high concentrations of radium-226 and radium-228 we ought to factor that in. So indeed we did a run on it and assumed the concentration. Well, they gave us the concentrations in the groundwater and we put them in and it came out 6.54 millisieverts per year. That's six-tenths of millirem. And we said because that is so small and because the people in Leadville that we're going to compare it to they drink surface water from melting snow in mountain streams and lakes and so forth, since that's the case, we would just neglect this. We felt we were justified in doing it.

Here's the summary for Amargosa Valley cosmic and terrestrial and radon and the total is

1.76.

Now we'll look at Leadville. Leadville is again at the 10,500 feet and a longest average number is 1.25 millisieverts per year. That is in NCRP Report 94 which was published in 1987. The chair of the group that developed that report was Dr. John Harley and the Director of Environmental Measurement Laboratory, DOE's lab in New York. And cosmic dose doesn't change. So we stuck with that number. It's well established. It's well quoted.

Once again, outdoors you just multiply it by two-tenths for the occupancy factor and it comes out 0.25. The reference. Sorry, jump back. This reference was another one we used to back ourselves up on Report 94. They did a lot of wonderful cosmic ray dose work and we just wanted to double check our numbers.

Now indoors, we divided Leadville for cosmic into indoors and outdoors but we also had it indoors during the summer and indoors during the winter. I'll get it out sooner or later. Okay. In the winter for the cosmic, accounting for structural shielding. Now the occupancy factor is four-tenths. That's half. Forty percent of the time is the winter. We assumed equal, six months of winter, six months of summer because again the librarian whom I talked to said they have snow early in the year and so we took that.

The prorate indoor summer thing would be 1.25 millisieverts per year times a building roof shielding factor decrease of 20 percent. So we've multiplied it by eight-tenths and then an occupancy factor of half of the 80 percent and we got that as the indoor for the summer.

Now for the winter, we again took the 1.25 but it had to be adjusted not only to account for structural shielding and occupancy but also for the snow cover. The snow cover you heard reduced it, the terrestrial, one percent per centimeter. Cosmic radiation in general is much higher energetic, relatively higher energetic photons than terrestrial radiation. So even knowing that, we still assumed one percent reduction per centimeter depth of snow.

Here we were in a quandary what to do but we assumed that it's three to four feet on the ground that it certainly won't stay on the roof at a depth of three to four feet. The sun and the heat in the house will warm it and it melts. So we assumed about 20 inches as I recall depth on the roofs.

If you want to pursue it further, I hope

EPA or NRC will, you can pick a better number or find that our number was reasonable. But anyway, doing that, again we think we over-estimated the reduction in the cosmic ray dose in the winter. So again, we're not making Leadville appear higher than it should.

And then assigning occupancy, it comes out that the indoor winter cosmic ray dose is 0.20 millisieverts. Then if you add the two together, you get four-tenths and two-tenths. You get six-tenths of a millisievert for cosmic radiation in a city such as Leadville with lots of snow. The last one wasn't a total. That one was a total for that portion. The total is actually here, 0.85 millisieverts.

Now the terrestrial dose rate outdoors and the terrestrial dose rate according to various reports and we can give the references was about 1.20 millisieverts per year and this compared to 1.17 in Oakley's EPA report of 1972. It compared to 0.90 for the Colorado Plateau. So we thought it looks like a reasonable number.

The references.

Then outdoors in the winter, the winter typical grounds snow cover is 90 to 127 centimeters. However, you don't walk on top of the snow. Either the husband or the wife goes out and shovels the sidewalk off. We figured if you do that, then you're going to get the full dose from the terrestrial regardless whether it's summer or winter. So that's what we assumed.

And on this is the outdoor dose rate for the entire year would be 1.20 and put in the occupancy factor and you have the dose.

Now the snow cover won't bother the internal dose from terrestrial radiation because the snow is not under your house. So that would be 1.20 times 80 percent occupancy factor and by eight-tenths for the shielding of the floors and so forth. So you get that for the indoor terrestrial. Then if you total them up. Well, for indoor we added in the building materials and according to NCRP Report 93 on consumer products, they estimated that the average increase in dose to people living in concrete or brick houses is about 7 millirem a year, .07 of a millisievert per year.

We assume that 40 to 50 percent as I recall of the homes in Leadville are concrete and so forth. So we estimated about 2 millirem, about 0.02 millisievert addition. Again you develop a better number. Put it in.

The reference is NCRP -- I'm sorry. It's

'95. I was saying it was '93. '93 was another one. Okay, '95. Now this is the total from terrestrial outdoors and indoors. It's the numbers that we've added there including the building materials and it comes out 1.13.

Now we had to do the outdoor radon for the summer. Here we used these people's work and they estimated a concentration of 31 Becquerels. We did the summer. Thirty-one Becquerels outdoors, six-tenths equilibrium, 880 hours for the summer, half of 1760 hours times the 9.6 and you get 0.16 millisieverts due to the prorated dose rate from outdoors.

The references. Go ahead.

Now outdoors in the winter, here you again if you have a better idea and can support it scientifically, full steam ahead. We knew that the winter snow cover essentially seals the radon in the soil. And you can say you said they shoveled off the sidewalks or they probably undoubtedly plow the streets. But the streets have the paving which also can be a sealant and even if you shoveled off a dirt walkway, moisture and all in that soil, moisture will have seeped down into it. Near the surface, it will be frozen. We just said we're going to assume it seals the radon during the winter in the soil, seals it and keeps it down there.

So what did we do? We assumed, again try your own technique and we encourage you to do so, we the concentration of radon in Leadville during the winter was the average for outdoor for the whole United States, the northern hemisphere air over continents. If it's six-tenths equilibrium there outdoors, winter, 880 hours, we got that dose rate from the radon.

Then Leadville outdoor total are those two. It comes out 0.20.

Leadville, indoors. Now here we used the Lawrence Berkeley Lab National database and we tended to favor it because they have compiled a databank that covers every county and every state in the United States and knowing the scientific quality and expertise of the people working at Lawrence Berkeley, we decided to go with that in contrast to using EPA's numbers. It's a wonderful databank. It not only gives the numbers but it gives the error range and loads of supporting information.

The average radon concentration in Leadville homes indoors is this, prorated eight-tenths for occupancy, coming out 3.47 millisieverts per year from radon.

The reference, I told you about it. Here's your website and all if you want to look it up.

Here's the summary for Leadville and I've repeated the Amargosa Valley here just so you can get a quick comparison. All the dose rates are in millisieverts. It came out if you total up all of these numbers 5.96 versus 1.76 and you're going to see now in spite of the point that EPA used a dose conversion factor for radon that was twice too high you still come up with a 4.2. Leadville is 4.2 millisieverts a year higher than the Amargosa Valley and the points there are that we have tried to be conservative in Leadville again according to my definition. We tried to be conservative in the Amargosa Valley.

CHAIRMAN RYAN: Dade, just a quick question. I just want to make sure I understood you right. You said that it would be 4.2 versus 1.76. Is that right?

DR. MOELLER: No. The difference in. This minus that.

CHAIRMAN RYAN: Okay. I just wanted to be clear about that.

DR. MOELLER: I'm sorry. 5.9 minus that.

CHAIRMAN RYAN: You said it right.

DR. MOELLER: Now the total again some number 90 percent of the difference is due to the fact that those people in Amargosa Valley don't live in conventional homes or 91 percent don't.

Here's the 4.2. Go ahead.

Again, we included the revised radon dose coefficient or dose conversion factor. We accounted for snow cover. We accounted for the removal of the snow. Now this is something that we could have accounted for and we avoided it because I didn't know what the right numbers were. But if the snow is covering the outdoor ground and you have a home over here it could increase the pressure gradient of the radon beneath that home.

Now the problem with that is, I don't know, does snow cover block away increasing? Does radon flow that far underground? I don't know. So we did not factor it in but it's one of our conservatisms.

We also assumed that the snow cover reduced the cosmic as the terrestrial. Now that may not be true and we did not account for ceiling fans.

For Colorado, we went through the same thing and I'll looking at the clock. So we're going to go rather rapidly. The State of Colorado, now we did not take account of snow cover because we had no data for the State as a totality and in general, I have lived and been in Nevada a long time, New Mexico and so forth. I've never lived any time in Colorado. But I just assume that snow cover may be there for a while but it's gone, meaning in the more inhabited areas.

The cosmic rate dose rate, this was Mauro's number. All of the Mauro and Briggs numbers had already been adjusted for structural shielding of the ceiling for cosmic and structural shielding for the floors for terrestrial. We had to extract that adjustment and at eight-tenths occupancy, let's rip along now.

Then we did indoors and then we summed them up for the total.

And then terrestrial we did just very straightforward. Occupancy factor for outdoors of 20 percent.

Then indoor terrestrial and then we got a total terrestrial of 48.

Then radon outdoors, we used the outdoor average concentration for Colorado and the occupancy factor of 20 percent, again 1760 hours.

Then their database, we used the indoor Lawrence Berkeley Lab database.

We got that. Then the total for radon in the State of Colorado is that, 3.06 and then here's the State of Colorado compared to the Amargosa Valley.

Now I'll subtract, 2.69 difference.

And then Nevada, let's just ripple through the Nevada. Here, Nevada bottom line is that. Let's go another slide or two.

See now, this is interesting. The difference between the State of Nevada and Amargosa Valley, the State is higher than the Amargosa Valley by 1.06 millisieverts on the average.

The mobile homes, the big difference. Keep going.

Here, several people have said and in fact in a sense what EPA tended to do was to compare the State of Colorado in essence to the State of Nevada although modified for the Amargosa Valley. We compared those two just to show you the difference.

Now here's the bottom line. If you compare the Amargosa Valley to Leadville, Leadville is 4.20 millisieverts higher. Compare it to Colorado, it's that. Compare it to the State of Nevada, it's that. So you can take your choice. An independent assessment, we think we're right on target with Leadville because we're comparing two comparable communities and we have site specific data and we think the uncertainties, they're still there but they're far less than they might have been.

Now what are your options? You could compare it to Leadville.

You could compare it to the State of Colorado.

You could compare it to the State of Nevada.

And the primary goal of this exercise was to provide all three, I don't know why and I don't know what agency "AND" is but it's one of them. We thought we used the best available scientific information. How people interpret it and so forth is a decision of theirs to make.

And one of the primary questions is back on that. The ICRP excludes large variations in dose rates from radon. However, in the newer 2005 proposed recommendation, they say the effective dose. But any kind of scientific work where you're comparing two groups, you don't want to choose some group that is way out of the normalcy, the normal picture, and try to claim that that's a good comparison. It isn't.

You've been waiting for the next slide patiently and I appreciate it. Thank you.

CHAIRMAN RYAN: Thanks, Dade. We appreciate the detailed presentation. Let me start with Jim Clarke this time. Do you have questions? Ruth?

MEMBER WEINER: I have a couple questions and as a sometime resident of Colorado, I have to tell you. They don't shovel the sidewalks in Leadville. You just wear your ski boots all the time. My overall question is what are the sources of the major uncertainties in your calculation.

DR. MOELLER: I would say the outdoor concentrations of radon. That's certainly an uncertainty because it baffles me. Everybody is worried about indoor but no one seems to be interested in measuring the outdoor. There are all types of uncertainties. I think I pointed out a number.

You've caught me on one, a large uncertainty. If they don't shovel the snow off, then the terrestrial is definitely reduced in the winter. Fortunately, that would not be a big number and outdoors is only two percent occupancy. So I'm trying to cover up for myself on that mistake.

I would love to have good solid

information on all of the input factors. Even the 1.25 millisieverts for the cosmic in Leadville which I pointed out is a long time honored estimate, I would like to see new data. So there are many uncertainties but they're in my opinion in our analysis far fewer than in comparing State of Colorado to State of Nevada.

MEMBER WEINER: What I was trying to lead to was just in your overall rough estimate, do you think the accumulated uncertainties would make a significant difference in your results or a not significant difference? Just what's your assessment of it?

DR. MOELLER: I am the world's worst to respond but I would say broadly speaking the results would not change that much. I think we have some pretty solid information.

MEMBER WEINER: I'm also curious. You used the Lawrence Berkeley estimates for everything except for Amargosa Valley and there you used Steve Maheras's. Did Lawrence Berkeley lab not cover Amargosa Valley?

DR. MOELLER: I think they had a number of Nye County and several times that flashed through my mind to compare the two and I never did it.

MEMBER WEINER: It was just one of those things.

DR. MOELLER: Yes, you're correct. Absolutely, that should have been done.

MEMBER WEINER: And finally, on the basis of your estimate of the natural doses to people who live in these places now, would you make any recommendation about the 15 millirem per year standard for the first 10,000 years?

DR. MOELLER: No, we didn't comment for example even on EPA's 3.5. We just showed what we got because we concluded upon reading EPA's proposed rule that we didn't see the science and we were looking for some science.

MEMBER WEINER: That was the purpose of yours.

DR. MOELLER: Yes.

MEMBER WEINER: Thank you.

DR. MOELLER: Thank you.

CHAIRMAN RYAN: Bill.

MEMBER HINZE: As usual, Dade, a very thorough presentation and excellent piece of work. Very interesting. As a sidebar, I might mention that you referred to the increase of terrestrial radiation with elevation on a general basis and this follows along with the general increase of heat flow in the terrestrial areas and that's due to the fact that in general the higher areas, the higher elevations, are associated with the lighter rocks and these are isostatically buoyed up just like a cork in a pail of water and those rocks are notably high in uranium and thorium. So there is very legitimate reason for that.

That really bears upon the question that I have. I'm kind of surprised that in view of the fact that Leadville and the reason that Leadville is named Leadville is that it's a mining area and this is an area where there are outcrops of these enriched uranium-thorium types of rocks and therefore the terrestrial radiation would be expected to be high there.

And this, I think, would be quite in contrast to the situation of Amargosa Valley where it is sitting out there on the sand flats and we have a difference of elevation. I don't know. Amargosa Valley has to be about 3,000, 3,500 feet versus 10,500. In my pass at it, these are quite different areas.

DR. MOELLER: Yes.

MEMBER HINZE: So I wonder why your comparison didn't take into account an area of

Colorado which would be much more comparable in my view from a geological, from a physiographic standpoint, than is Leadville.

DR. MOELLER: We did not identify an area where there were data, the detailed data, that we wanted. Now maybe we should have used, I'm trying to think. There's one town that they've done a lot of radon measurements in that escapes me at the moment. I'll think of it in Colorado. But we did not find like Maheras's report. We didn't find a Maheras report for any community in Colorado.

MEMBER HINZE: I see. Okay. Thank you.

CHAIRMAN RYAN: Allen.

CHAIRMAN RYAN: Dade, again, it's a fascinating presentation. I second Bill's comment. When I think about your result, you get a comparison that says there's a difference on the order of 425. I think folks jump to the idea that that compares in some way to 350 and I guess I'd caution that thinking that with uncertainties they may in fact be the same number.

And it's sort of begs a question in my mind. What do we do about the statistics or the uncertainty analysis in a more rigorous for these or any other estimates that we want to use to establish this against the background kind of concept and in even a generic way, not necessarily related to the standard? Do you have any thoughts on that? Could we pick Leadville and ten other communities or do you think this exercise should be repeated?

DR. MOELLER: It probably should be repeated independently because not only was it independent but it was almost me and I think other opinions should be factored in.

Now one thing we did do which was of interest to me, we took the average for Colorado minus the average for Nevada and then we doubled that difference and it was close. Our difference between Colorado and Nevada as we calculated it was roughly half of 3.5. So it shows that EPA in taking a short cut and assuming 100 percent occupancy and all those other things they weren't that far off other than being twice too high.

CHAIRMAN RYAN: And I think some of those kinds of analyses perhaps are the next steps to really assess what you've done and to me, I take away a couple of points and tell me if you think I'm right. One is that you really need to be pretty rigorous and account for things that you even think are small and I think Dr. Garrick would agree that if you just assume a conservative value it may be masking uncertainty or masking the true answer. So that lesson is one that I think we clearly take away that you really have to treat all the components even the small ones carefully.

DR. MOELLER: Yes, and that's what we tried to do. Like to have estimated Amargosa Valley and never given thought one to what they live in and I must admit. When I got into it, I never thought of that. But I had searched the literature as thoroughly as I could and there it was big as a mountain in front of me. There's no way I could avoid it.

CHAIRMAN RYAN: The second point that I take away is that I think to really understand the choice of a given number over another you really probably need to think about how you would either evaluate uncertainties in a limited number of exercises a little bit more formally or to do the same exercise with the same rigor that you've done in a number of comparative communities that you can establish a basis for comparison on. Is that a fair comment?

DR. MOELLER: Yes, and again if the committee wants that done and if EPA/NRC/DOE is interested, we'd certainly be willing to undertake it.

It would be probably be other people in the company because I'm not really qualified to delve into the uncertainties. But certainly, we have the people.

CHAIRMAN RYAN: Okay.

DR. MOELLER: And I also want to say as of this point, we are pretty much, we've gifted all we're going to give. It could go on and on. I've put 200 hours into this I'm sure.

CHAIRMAN RYAN: And maybe when Dr. Tenforde comes up after lunch break, he'll tell us a little bit about the update to the background report that I think NCRP is working on. So maybe we'll get some further insights and get some understanding of where that kind of assessment may be going.

DR. MOELLER: And a lot of what you're saying, Tom was telling me all these subcommittees of the scientific community that he has. They're delving into all of this and it's just not something -- I could ask him. How many people are involved, Tom?

DR. TENFORDE: I'm Tom Tenforde, President of NCRP. The committee itself has 37 members and we have a couple of technical consultants assisting the committee.

DR. MOELLER: You see, we can't compete with that. And you know we're not interested in competing.

CHAIRMAN RYAN: And again, I'm certainly taking from your presentation an endorsement of a rather rigorous and detailed look perhaps as the NRCP is undertaking.

DR. MOELLER: Definitely.

CHAIRMAN RYAN: It is there that I think not only will good average numbers come forward but perhaps some better approaches to and insights into uncertainty might be coming forward.

DR. MOELLER: And if you have, I'm sure this is a bias statement, people from the Environmental Measurements Lab in New York, the DOE lab, they've done loads of studies. Carl Gogolak, I've talked to him and he helped me a lot. There are a lot of good people there.

CHAIRMAN RYAN: Thank you. Any other questions? Comments?

DR. MOELLER: Thank you.

CHAIRMAN RYAN: Thank you very much.

DR. MOELLER: Thank you for your patience. You can tell someone you heard a speaker with 107 slides.

PARTICIPANT: That's a movie.

CHAIRMAN RYAN: In record time. Thank

you. Based on our hour, I'm going to suggest. Tom, would you like to begin now and we'll just run a few minutes long or wait until after lunch? It's your choice. Let me hasten to add that based on the interest from folks that might want to attend as the schedule is published, we could break now and just resume at our normal hour.

John, what do you think would be best? That gives you a full measure or if we wanted to switch order of folks or whatever we could. But I guess my first choice is maybe we'll just adjourn here and reconvene at our session at 1:30 p.m. That way we're on schedule and you could pick up there and we're not short-changing anybody that might want to participate. Is that all right?

DIRECTOR LARKINS: That's fine. We could change the order of speakers. I don't know that it would matter necessarily.

CHAIRMAN RYAN: Why don't we just stick with our original game plan? Then we'll just have a little longer lunch break for everybody's benefit if that's all right. Thanks Tom. All right. With that and no other comments or questions at this, we'll adjourn until 1:30 p.m. when we're resume our afternoon session. Thank you.

(Whereupon, at 11:38 a.m., the above-entitled matter recessed to reconvene at 1:31 p.m. the same day.)

CHAIRMAN RYAN: Dr. Tenforde will offer his views on the EPA proposed standard revision.

DR. TENFORDE: Thank you.

CHAIRMAN RYAN: Welcome, Dr. Tenforde.

DR. TENFORDE: Thank you. I'd like to thank you, Dr. Ryan, and the entire committee for inviting me to provide some of my personal perspectives on the EPA proposed regulations on Yucca Mountain public doses.

I want to emphasize from the outset and for the record that the views I'm presenting today are my own as a radiobiologist and biophysicist and do not represent any official views of my organization NCRP.

I also have some good news and some bad news. The good news is that I only have a fourth as many slides as my honorable colleague, Dr. Moeller. The bad news is he talks twice as fast as I do.

(Laughter.)

DR. TENFORDE: Well, let me just briefly indicate the topics I'd like to discuss with you. First, although I think nearly everyone here is aware of NCRP, I'd like to just quickly summarize our charter and our missions and some of our scientific reports, a number of which I will refer to during the course of my presentation.

Secondly, I would like to give a historical perspective on public dose limits. I think it's interesting to put the Yucca Mountain recommendations in the context of the evolution of public dose limits over the last five decades.

Third, I'll provide a critique, emphasizing, again, my personal views on EPA's recommended public dose limit for less than 10,000 years and then for the long term out to one million years, the period of projected geologic stability.

And then finally I'll summarize the recommendations on some alternative public dose limits that I would like to recommend hopefully for fairly well founded reasons.

Historically NCRP is now in its 76th year. It was founded shortly after the Second International Congress of Radiology in 1928, and at that event ICRP was officially formed, and the representatives from many nations were encouraged to begin similar organizations in their own country, and a young physicist in his mid 20s at the time, Lauriston Taylor working with NBS came back and founded the U.S.

Advisory Committee on X-ray and Radium Protection.

Of course, in those days the use of X-rays in medicine and the use of radium both for medicine and other applications were the main health protection issues, and over the next 15 years, many reports were produced by this advisory committee.

Then after the A bombs, of course, the range of radiations for which there were health protection concerns, as well as measurement issues, grew tremendously and the original committee was changed to the U.S. National Committee on Radiation Protection and greatly expanded in size and scope.

Finally, in 1964 under Public Law 88-376, NCRP was formally chartered by the United States Congress. Laurie Taylor was the chairman of these committees and served as president of NCRP for the first 13 years of its existence, and we were all saddened when he died shortly after Thanksgiving last year, but it was at the age of 102, and he certainly had a life and career to be very proud of. He was certainly a leader in radiation measurements and health protection through much of the 20th century.

The key elements of the charter are these four items. First, NCRP under its mission is to provide information and recommendations on protection against radiation and radiation measurements quantities and units.

Secondly, and very importantly, we are charged with developing the basic concepts, the scientific principles that underlie radiation protection limits.

And the third and fourth items are ones that I've been putting a lot of emphasis on in my term as president for the last three and a half years, and that is to facilitate effective use of the combined resources of organizations that are concerned with radiation protection, including a number of international organizations with whom I've been trying to strengthen our relations, ICRP being one example.

Since being founded, we have had four productive decades. We are now issuing report number 150 as of next month, and since 1964, we have published 121 full reports and more than 90 other documents, including our commentary statements, proceedings of our annual conference, which are published for the last several years in the Health Physics Journal.

We've enjoyed our relationship with Dr. Ryan in his capacity as Editor-in-Chief, and Taylor lectures are also published there in the president's reports that we've begun issuing in the last few years.

There are a number of contributions I'd like to just summarize in five bullets. Certainly our reports on basic exposure criteria and their scientific basis are well known in the United States and worldwide.

We've done a great deal of work on population exposures, as Dr. Moeller mentioned. One of our reports and a number of satellite reports that's widely cited was Report 93, but that was published 18 years ago, and times have changed. Indeed, medical exposures today are much higher than they were then, largely due to the use of CT, and the radon exposure estimates have gone somewhat down, in fact, significantly downward, as Dr. Moeller has shown, I think, very well and is also included in an upcoming NCRP report.

We are currently updating the older reports. As I mentioned before, we have this huge, 37-member committee, and I think that will be an effort that will be complete in about two and a half to three years.

We have many reports on radiation protection practices and industry in medicine with a growing emphasis on medical practice and good support for that from the National Institutes of Health.

Environmental radiation and, in particular, waste disposition and management has been a topic of many recent reports, and I'll very briefly summarize them in a moment.

And then radiation dosimetry and measurements has been a traditional area, and that is once again growing. We have reports underway on uncertainties in measurement and dosimetry of both external radiation and internal radiation, and those committees are fairly -- the one is fairly far along, the one on external radiation, and the one on internal dosimetry uncertainties is just at the starting point, but within two to three years we expect these reports to be published, and they should be extremely useful.

Let me just give you a very quick tour through some recent reports and reports that will be issued in the coming year, and the reason for doing this is not just to show off that NCRP had published a lot, but I will refer to a number of these reports as I make my comments related to Yucca Mountain.

Report 129 was issued in 1999 on screening limits for contaminated surface soil.

Report 139 was produced by a committee

chaired by Dr. Croff, and it's on risk based classification of radioactive and hazardous chemical waste, a very useful report that tried to put different types of hazards on a common ground using a risk index, and there are many, many applications of this, Ellen. I keep thinking of more almost every day, and we're going to make very good use of this, as others have already.

Report 141 was on managing disposition of potentially radioactive scrap metal, a huge issue for the nuclear industry. There will be many reactors decommissioned, probably about eight million metric tons of slightly radioactive of nonradioactive scrap metal and about ten times that much concrete will be generated, and the issue is what to do with it. What are the clearance and possible release criteria for that?

This report, I think has been very useful to NRC amongst others.

Then report 143 was on managing the development of management techniques for small administrational generators to minimize the off-site disposal of low level waste.

And I think this also has proved to be very useful.

Now, Report 146 I will come back to because this really, I think, is one of the most important environmental reports we've published in recent years. The goal of this report was to compare the closure guidance from EPA under CERCLA and NRC under the license termination rule on remediating radioactively contaminated and decommissioned nuclear sites.

This report discusses both commonalities and differences between dose based and risk based remediation goals, and it demonstrates, I think, very clearly -- and I'll come back to this -- that the interpretation of federal guidance is very dependent on exposure scenarios.

And then finally, this report, I think, brings home very clearly with a number of examples where there is a definite need for collective decision making on remediation goals involving representatives of federal and state regulatory organizations, as well as members of the public. The public really needs to be factored into the decision process, and there are some excellent examples of that, for example, at West Valley.

This year we held our annual meeting on managing disposition of low activity radioactive materials. There were participants representing stakeholder groups from industry, regulatory authorities, consumer groups, and the general public. All of the papers are in. They're undergoing rigorous peer review, and I expect they will be published by the middle of next year in the Health Physics Journal.

We have other reports that are in the final stage of preparation. I think this one is a very important report that will be welcomed by federal agencies on performance assessment on near surface radioactive waste facilities, and that is currently in final stages of comment resolution from the peer reviewers who are members of NCRP Council, and I expect this will actually be published by the end of this year.

Scientific committee, 6422 on design of effective effluent and environmental monitoring programs, has completed a draft of its report. It's currently being edited and the references validated and all the things we owe are just routinely due before it goes to counsel for review, and that should happen early in next year. There's a possibility the report may be issued next year.

Cesium in the environment is a report that's being looked forward to by many. This is really the definitive compendium of information on cesium, including all of its environmental pathways, bioaccumulation, and so forth.

This report is also now in a complete draft form, and is undergoing rigorous editing procedures prior to submission to counsel for review. I do expect this report to be published in 2006 as well.

So we do have a lot of work that's either recently been completed or will soon be completed that's relevant to management disposition of nuclear materials, and I will reference some of these as I go forward in my presentation. What I'd like to do now is just give you a quick tour through the evolution of public dose limits over the last four to five decades. I'll focus on NCRP. I've done this analysis for ICRP also, although I won't go through all of the details for ICRP.

In 1971, the first formal recommended standards for public exposure were issued in Report 39 recommending a 500 millirem per year public standard.

Then in 1984 at the time of the Clean Air Act, EPA asked us to do a quick study on and make recommendations on control of air emissions radionuclides, and it was recommended that the exposure under continuous conditions of a member of the population should not exceed one millisievert per year.

Infrequent or noncontinuous exposures could reach a level of five millisieverts. I will come back to that in a later document.

And then it was clearly emphasized in that statement that's very short, several pages, that recommendations on limits are really only part of a total system of dose limitation which must include justification, ALARA or optimization as ICRP calls it, and individual dose limitation.

Now, a very important additional provision was added in Statement No. 6 that I believe is relevant to the Yucca Mountain standards, and so I'll spend a little time discussing this. I won't read this word by word, but basically what is recommended in Statement 6 is that if you have potentially multiple dominant sites of exposure of members of the public, that the limit for any one source under the control of an individual or single management group must not exceed 25 percent of the one millisievert per year annual limit. This is basically saying you could have four dominant sources of radiation, and if you follow this guideline, then you're going to maintain the exposure of any individual in the public to less than one millisievert per year.

And I believe this is a very important, new concept that was first discussed in Statement No. 6 a little over 20 years ago.

In Report 91 on recommendations of limits for exposure to ionizing radiation, NCRP recommended the effective dose limit should not exceed one millisievert per year for any individual, and for infrequent annual exposures, while that is not really quantified. Infrequent has the context of being something that might occur, oh, once a year or a few times in a lifetime, but not often. It was recommended that an annual dose of up to five millisievert per year be allowed, and again, it reemphasized the recommendation of Statement 6 that under conditions where individuals are potentially exposed to multiple sources at multiple sites with different operators, no individual site should provide or cause more than one quarter of a millisievert effective dose to that individual.

And this report also first introduced the concept of negligible individual dose of one millirem per year.

In 1993, the report that you're probably all most familiar with on limitation of exposure to ionizing radiation, it contained the same public dose limit recommendations as in Report 91, and it added the cautionary statement that under conditions where an individual receives up to five millisievert on an infrequent basis, that over a period of years the average exposure of this individual should not exceed about one millisievert per year.

And it also adopted the .25 millisievert per year recommendation on limits from any individual single source.

ICRP has evolved over the years in a very similar way. I won't trace the history, but the recommendations that are most cited, of course, are Report 60 and the recent recommended update of Report 60, which is still in a discussion phase, but this, again, endorsed the public exposure limit of one millisievert per year and specified that larger exposures can be allowed in a single year provided that the average exposure over five consecutive years does not exceed one millisievert per year.

So they were a little bit more quantitative in defining the averaging period and the concept of infrequent or noncontinuous exposure. They followed NCRP in terms of making a recommendation on a constraint for any single source of .3 millisievert per year, 30 millirem, and the idea there was basically that there might be three dominant sources. NCRP allowed for as many perhaps as four dominant sources where if you maintained the limit at a quarter of a millisievert, you wouldn't exceed one millisievert per year. In the case of ICRP they wanted to be a little different than us, I guess, so they recommended .3 of a millisievert, which is really an almost indistinguishably different recommendation.

Now, I do want to point out because I'll come back to this that regulatory recommendations on limits are often very scenario dependent, and NCRP has recognized this for many years, and we had many reports, the latest being Statement No. 10 issued last year, and the reason that I backed that publication was because there seemed to be a lot of confusion about exceptions to the public dose limits that have been recommended by both NCRP and ICRP, and we went through a lot of scenarios where there are exceptions and exposures that differ from the basic recommendation.

The basic public dose limit is one millisievert per year, period, but there are circumstances under which different exposures can occur. For example, a family member caring for a patient that receives high dose radionuclide therapy can receive up to 50 millisievert, five rem, with appropriate training and monitoring.

Secondly, we have recommended in Commentary 17 that under security screening for purposes of homeland security, stowaways in cargo containers can receive up to five millisievert, and that's been looked at very seriously by TSA, for example.

For lifesaving measures, exposure of an individual during emergency operations can approach or exceed half a sievert, 50 rem under conditions where the exposure involves a large part of the body for short periods of time, and this you'll find in our commentary that's about to be issued on radiation protection for first responders.

Then exposure to the embryo/fetus should not exceed half a millisievert per month.

So those are some of the main examples of scenario dependent exceptions to the basic guideline of one millisievert per year.

Now, I'd like to turn to the EPA proposed regulations under 40 CFR 191 for the period up to 10,000 years. EPA has recommended their generic risk-based public dose limit of .15 millisievert per year that has been used in a number of different scenarios by EPA, including, for example, CERCLA requirements on the clean-up of a contaminated site, the WIPP, the waste isolation pilot plant project public dose limit is specified at 15 millirem per year, and so there's a lot of history here behind this recommendation, and they've specified in 40 CFR 197 that compliance should be based on design considerations based on a rural resident exposure scenario of a reasonably maximal exposed individual in Amargosa Valley or nearby and not based on a subsistence farmer.

And I'll come back in a moment to show why this scenario is so important in interpreting the proposed EPA regulation.

And they also specified that existing groundwater standards should be imposed.

Now, this is a summary of one of the conclusions from our Report No. 146 comparing risk management in the decommissioning of nuclear sites and the subsequent clean-up, comparing the risk-based approach of EPA under CERCLA and the dose based approach of NRC under the license termination rule.

The committee that prepared this report concluded that you simply cannot just look at the numbers of 15 millirem per year recommended by EPA versus 25 millirem per year recommended by NRC because the interpretation of those numbers depends so much upon the exposure scenario.

And in this case, comparing CERCLA and the license termination rule recommendations for EPA, they commonly us a scenario the 30-year exposure to a suburban resident or a rural resident, as it's called here in the Yucca Mountain context, who doesn't drink the groundwater or doesn't eat food produced on the remediated site.

In contrast, NRC usually uses a lifetime exposure to a resident farmer, drinks the groundwater, eats food produced on the remediated site, and NRC also recommends the use of measures that achieve ALARA exposures.

So there are very fundamental differences in the scenario and the context in which to view a recommendation such as EPA's 15 millirem per year, and when you get to the bottom line and compare the impact of different exposure scenarios on the meaning of these dose-based limits, it really obscures differences between them, and so I think that's very important to keep in mind.

These are not hard and fast numbers.

Their interpretation and their implementation in practice really depends a lot on your exposure assumptions.

Well, let me turn to a critique of the public dose limit proposed in 40 CFR 191. First, Yucca Mountain is a single NRC radiation source maintained by one primary operator, DOE and its subcontractors, and it is my view -- and I emphasize personal view -- that if you look at the history of development of regulations for individual sites of public exposure to radiation, then I believe that the limits, the appropriate limits of the regulations on a new radiation source rather than relying upon generic risk-based limits for remediated nuclear waste sites.

And it is a given that other radiation exposures to members of the public from manmade sources are unknown, but they must be limited to one millisievert per year total exposure, and it is my view that the regulations for the public in the neighborhood of Yucca Mountain should, therefore, be consistent with consensus national and international public dose constraints of either one quarter of a millisievert per year in the case of NCRP or one third of a millisievert per year in the case of ICRP for any given single source.

I'm basically saying I think that many of the considerations of EPA were correct and proper, but I believe they really impose the wrong limit and that the appropriate limit would be a consensus national or international limit based on radiation protection against a single source of radiation under the control of a single operator.

Now, I'd like to give some further arguments for using these international or national limits rather than the EPA generic limits. First of all, the guidelines from NCRP and ICRP and others are dynamic, and they're driven by new scientific knowledge on radiation health effects.

In general, these guidelines are designed to limit maximally exposed individuals and are not strongly scenario dependent. There are some exceptions I mentioned before, but those aren't really relevant to this particular scenario of individuals exposed near Yucca Mountain, and so I think you want some regulations that are designed to protect the maximally exposed individual.

And I am concerned that EPA's regulatory process may not be adequately responsive to new scientific knowledge that can strongly impact national and international recommendations on public dose limits.

Let me put my radiobiology hat on and talk about some of those. I anticipate some significant changes in regulatory ideas and concepts over the coming decades and perhaps beyond.

First, as I'm sure all of you know, there is a very large study headed by DOE with support from NASA as well, looking at non-targeted radiation effects, bi-standard effects, genomic instability, adaptation to radiation.

And in due time as those effects are better understood and translated from the single cell level up to the tissue and organ and whole animal level, it may have some impact on the estimate of dose response characteristics at low doses.

Secondly, through studies on Japanese bomb survivors and others, we are getting an improved understanding of the risk of potentially fatal non-cancer diseases caused by radiation. We don't have good risk coefficients yet, but we do know these exist and that they are significant, including, for example, cardiovascular nervous tissue diseases.

I think there will also be an impact on our understanding of radiation effects through the growing field of molecular epidemiology, looking for early, intermediate, and late markers of disease, and this could have some impact ultimately on our estimate of dose response characteristics and suitable radiation protection measures.

And then finally, it's important to emphasize that medical technology is evolving very rapidly, and methods for identifying, treating, and preventing radiation induced illnesses can be anticipated over the coming years, and this was emphasized ten years ago in NCRP Report No. 121, and I do believe we are beginning to see directions within medicine that may lead to some very significant advances in managing disease caused by radiation, and this could also have some influence on consensus public dose limits.

So to get to the bottom line, my first recommendation on the Yucca Mountain public dose limit for less than 10,000 years post closure is that a national consensus recommendation of NCRP for limiting annual exposure of individual members of the public to less than one quarter of a millisievert or 25 millirem from a single source be employed as the regulatory criterion.

I believe that the application of this

limit should have no time restriction, that it should go well beyond 10,000 years, and that it should be modified as appropriate in accord with science based changes in national and international consensus guidelines on public exposure, and this should be at any time post closure of the Yucca Mountain repository, not just within the first 10,000 years.

Let me turn now to the recommendation of 3.5 millisievert per year, at times in excess of 10,000 years post closure maintained up to a million years, which is the projected period of geologic stability.

The argument in support of this increase, as discussed by Dr. Moeller and which you're all familiar with, I'm sure, is to compare differences in background radiation exposure residence in Colorado compared to Nevada, and particularly in Amargosa County.

In some ways this is not intended as an environmental justice type argument, but it has the flavor of that in a sense. It's basically saying look at the background of the residents near Yucca Mountain and look at a comparable location in a neighboring state, Colorado. There is a difference of they have estimated of about three and a half millisieverts which may not be quite right based on Dr. Moeller's analysis, but it's not terribly far off, and then say that, well, that's the amount of exposure you could allow from a manmade source at Yucca Mountain.

Now, you know, I want to point out that in many documents by NCRP and ICRP and others it is, I think, generally recognized that you cannot do a side by side comparison of exposures from natural background radiation and manmade radiation. There are many reasons for this. The mix in qualities and types of radiation may differ and the dose rates at which people receive the radiation from those sources can be very different, and so in a way there's a bit of an apples in comparison here if you say that background plus radiation from Yucca Mountain in Nevada near the site should not exceed that of background radiation on a routine basis of residents of Colorado.

So I don't completely agree with the arguments there, and let me though say that natural background has been a major factor in many of the regulatory activities of NCRP and ICR -- not regulatory, but dose limit recommendations -- of NCRP and ICRP for several decades. I did a little historical search and discovered that in 1959 an ad hoc committee of NCRP that was chaired by Lauriston

Taylor discussed various options for recommending maximum permissible public doses. They considered using a fraction of the occupational dose limit, let's say, one-tenth, compared to other risk and light, and we know that in the public it's about ten to the minus four to ten to the minus five per year, or in comparison to natural background radiation, which excluding radon is on the order of a millisievert per year.

And that committee, very prestigious health protection experts and radiobiologists decided that the third option is really probably the most appropriate benchmark.

Now, actually, interestingly, in the 1970s when Report 39 was issued recommending one half or I should say five millisieverts per year, that options one and two were very major considerations of the committee. They limited the public dose to one-tenth of the occupational dose limit, and they made some direct comparison to other risks, and they did consider background, but didn't really put that up front.

Interestingly, by the early 1980s, when the recommended regulations on the public dose limits was changed to one millisievert to five millisieverts, you'll find all of the subsequent reports discussed at some length, the natural background radiation levels, and compared them to the recommended public dose limit of one millisievert per year.

So there's a long history of comparing radiation doses from background sources with doses from manmade sources.

Let me give you a critique from my own perspective of the public dose limit recommended by EPA after 10,000 years. I believe that this large step-wise change, 23-fold change at 10,000 years is a rather difficult change to justify within a regulatory framework. Normally government and state and other regulators don't do things that way. They don't make order of magnitude adjustments.

And it's rather difficult not only to justify scientifically or sociopolitically. It's also very difficult to implement, and I believe that this really does raise a very fundamental question of intergenerational equity. Over the next 1,000 years, there will be about 350 generations. Over the next 10,000 years, multiply that by ten, you're looking at 3,500 generations.

And here, today in 2005, some regulations are being recommended that are of much higher doses that would be experienced by these generations far in the future than would be experienced by people living at this time. And I really question the equity of making such recommendations.

So my recommendation is that, first, I believe that the pre-10,000 year public dose limit should be continued with the understanding that that limit will be changed based upon science based changes in national and international consensus organization recommendations. We need to bring science into the picture, and that's one way to do it, and I do see some merit in looking at background. I wouldn't argue with that point at all.

But I would view the three and a half millisieverts per year as really a recommended maximum level or ceiling for exposure of any member of the public should there be a need to impose that. There may well not be any need.

It could be that the design assumptions for Yucca Mountain are sufficiently conservative and that there won't be major seismic or volcanic events or human intrusion events, and it could well be that the dose levels will not increase dramatically over the next several millennia.

And should there be a need, however, for some approach to deal with such circumstances, then I think that this would not be an unreasonable level to set as a maximum for exposure of any member of the public.

And, of course, if it is necessary to impose controls, then there are lots of ways of doing that, one of which is to increase the size of the controlled area relative to what's specified in 40 CFR 197, restrict use of contaminated water, and so forth.

So there are ways to deal with a large increase in the radiation from this source.

Well, let me summarize. This is my last slide. My personal opinion is that Yucca Mountain should be subject to public dose limits recommended by NCRP and very similar recommendations from ICRP of limiting the public dose to a quarter of a millisievert per year, treating Yucca Mountain as a single radiation source under the control of a single operator, and this would be the limit for a maximally exposed individual in Amargosa County or nearby.

I believe that this limit should be updated, in step with science based evolution of national and international consensus guidelines on acceptable dose limits, and this would be an ongoing process with no specific time frame. It would go on well beyond 10,000 years one would hope.

And if necessary for regulatory control, one possible future approach would be to utilize the difference in background in Nevada and Colorado or some other similar comparison, such as Dr. Moeller discussed, of about three and a half millisieverts per year as a recommended maximum level, not a median, but a maximum level for exposure of any member of the public.

And finally, I'd like to end on a cautionary note because I think we all recognize it's impossible to know to any precision the level of radiation exposure from Yucca Mountain or, for that matter, natural background levels of radiation. They could be significantly impacted by seismic events or volcanic events, et cetera, over the next million years.

I think that there should be flexibility built into the regulations in a way that is fully consistent with protection of public health.

So with that, I'll conclude. I'd be happy to answer any questions, and thanks again for allowing me to express my thoughts on this subject.

CHAIRMAN RYAN: Tom, thank you very much. We appreciate your well thought out and well delivered presentation.

I'd like to start with just a couple of questions. If I understand 116, the public dose limit is 100 millirem per year, and then it goes to 25 if you have multiple sources, particularly if you don't know.

DR. TENFORDE: Right, exactly.

CHAIRMAN RYAN: In the cast of Yucca Mountain, I would suggest that perhaps we do know. There are no other sources perhaps.

DR. TENFORDE: That's right. As I've pointed out --

CHAIRMAN RYAN: Did you change your mind and then move to 100?

DR. TENFORDE: Oh, well, what I said was based on the idea it is a single source under the control of a single operator. That's a very important component of that argument and as such, it should be subject to 25 millirem.

CHAIRMAN RYAN: But that to me doesn't gibe exactly with the 100 millirem or one millisievert standard from any single source, given you know there are no other ones.

DR. TENFORDE: If you know that.

CHAIRMAN RYAN: Yeah.

DR. TENFORDE: But, I mean, do you really --

CHAIRMAN RYAN: In New York City you might not, but in Yucca Mountain you might. I'm just asking a question if that turned out to be the case.

DR. TENFORDE: There might be rural residents who are working with DOE or a contractor organization and getting some occupational exposure.

CHAIRMAN RYAN: Sure, but I'm just asking. I think it's an interesting thought to think about because it is probably one of the more rural places, but --

DR. TENFORDE: And they might discover some minerals that are worth mining --

CHAIRMAN RYAN: Sure.

DR. TENFORDE: -- somewhere south. Who knows?

CHAIRMAN RYAN: Sure, but that door is open, I guess.

DR. TENFORDE: It is.

CHAIRMAN RYAN: Okay. The other one, I just wanted to touch on. It was a few slides ago when you talked about some of the recent radiobiology. I was curious if you could give us your insights. So could you back up? I'm sorry. There's no slide numbers here. It's factors that could significantly influence recommendations.

DR. TENFORDE: Yes.

CHAIRMAN RYAN: There we are. And tell us your thoughts on BIER VII and what's coming after BIER VII because they seem to have commented on some of those key issues you mentioned in the first bullet and basically said at this point there doesn't seem to be any conclusive or directive information at hand.

DR. TENFORDE: Well, first of all, in defense of BIER VII --

CHAIRMAN RYAN: Well, I'm not criticizing it.

DR. TENFORDE: No, I mean, I know you're not --

CHAIRMAN RYAN: I'm just saying that's what they --

DR. TENFORDE: -- criticizing it, but the Director of the Office of Science at DOE wrote a stinging letter to the President of the National Academy criticizing the report as being inadequate and scientifically poorly done, and there was a toe stepped on there, and that is that DOE is the main sponsor of research on non-targeted radiation effects, and they don't want anything to get in the way of the

$30 million a year in research funding, and I hope nothing does.

The thing that is misunderstood about BIER VII, and in part it's the Academy's fault for the way it was advertised before it was released, is if you read it carefully, they're basically saying that they're looking at radiation health effects above the level of 20 rem.

The emphasis of the DOE program is on doses below five rem because when you look at bystander effects and adaptation and genomic instability, they could have some very significant effects down in that low dose range where your epidemiology data is in the noise, and if you could understand that and translate it to the human level, you might predict a different dose response curve.

And we would expect, for example, the bystander effect is going to plateau out. That's where you have a few cells hid in a group of cells, and the others suffer injury as a result due to transmissible factors, humoral factors, whatever.

And so the impact of these non-target effects will largely be at very low doses, well below what BIER VII considered.

And they didn't make that really clear in their press release, but if you read the report, they're pretty candid about it.

The direction things could go in terms of recommended exposure limits vary for each of these. They can go up or go down. I think as we understand potential nonfatal cancer effects, it's going to have a significant impact on the risk coefficient. There is some discussion of that in BIER VII, although they don't come out and give quantitative estimates, but if you look at the evolving Japanese data on non-cancer effects, you can see it's a significant fraction of the number of cancer incidences or fatal cancers, and so this could increase our conservatism on public doses if it plays out that way.

What epidemiology will tell us at the molecular scale I have really no idea. It could go either way, and then certainly advances in medical technology would tend to mitigate estimates of risk for humans.

CHAIRMAN RYAN: That's really the clarification that's real helpful on this slide, is that there are some that would move things up or down the risk scale based on at least early indications that perhaps could be either way, but that's really a helpful clarification. Thanks.

DR. TENFORDE: Oh, you're welcome.

CHAIRMAN RYAN: And then the third to last slide with critique of EPA's proposed public dose limit. The first bullet caught my eye. Large step-wise increases in the public dose limit at 10,000 years is difficult to justify in a regulatory framework, but earlier on you gave us, if you take 25 as the number and you allow 500, that's a pretty significant factor increase for the care giver example.

DR. TENFORDE: Yeah.

CHAIRMAN RYAN: So there are justified increases in a regulatory framework. It happens to be a specific case.

DR. TENFORDE: But that's an uncommon event.

CHAIRMAN RYAN: Oh, it's not uncommon at all.

DR. TENFORDE: No, no, for an individual it's an uncommon event. For example, how many times would you expect a family member to have to care for a fellow family member that's treated with high dose nuclear medicine technology that might occur once or maybe twice in the lifetime of the caregiver? That's a very different scenario than you have with a more or less continuous exposure at this much higher level.

CHAIRMAN RYAN: Yeah, and again, I guess I would think a little bit further about that before I concluded as boldly as you have that it's difficult to justify because that limit at the dose may be for the REMI (phonetic) or a critical group, not, you know, the population at large, and if you take all caregivers as a group, that's not a trivial number of folks either.

DR. TENFORDE: Collectively, you're right.

CHAIRMAN RYAN: So just a little caution, not a criticism, but just a caution that I think there are lots of examples where we will allow exceptions, and you mentioned several: emergency responders, and you know, there are several others in your list, and some are okay in a regulatory framework, and it's the details of individual doses, repeats, collected dose perhaps, even though I don't think much of collective dose as a useful metric. That can allow you to at least do comparisons perhaps, but I just urge some caution when we think about the details that really tell you what's what.

CHAIRMAN RYAN: But one common theme here for these people who are permitted to get higher doses than an average member of the public is that it's done under conditions where they are trained and monitored. So we know what they receive and we can mitigate effects, both in advance and following their high radiation exposures, and --

CHAIRMAN RYAN: There is one exception, and that is the patient.

DR. TENFORDE: Well, we're out of --

CHAIRMAN RYAN: Not recorded. I mean, the machines are regulated very carefully and all of that, but dose to the patient is a whole separate arena.

DR. TENFORDE: Well, it is, but remember we're not entering the medical theater here.

CHAIRMAN RYAN: But on an individual basis, for me as an individual, when I think about my radiation exposure, I think about my occupation, my plane rides, and my medical exposure. That's where my risk comes from.

So, again, I think that is at least instructive to think about individual procedures and procedures that one gets over a lifetime at least having some insight as to acceptable risk.

DR. TENFORDE: Well, they are a form of benchmark for preparing inadvertent or unknown exposures as a member of the public.

CHAIRMAN RYAN: Right. Thanks, Tom.

Again, I appreciate the insights and the clarifications.

Jim, let's go to you.

MR. CLARKE: Could you take us to the last slide, please?

DR. TENFORDE: I'll take you there.

MR. CLARKE: There you go. Your second bullet, I like that. It makes a lot of sense. I just wondered how you see that playing out, given the fact that compliance will have to be demonstrated in advance to a standard whatever it is at that time.

DR. TENFORDE: Well, it's hard to predict. I mean, as I mentioned before, we saw a fivefold decrease in the acceptable limit of public exposure between the 1970s and the 1980s. So there could be step-wise increases or decreases depending on the growth of our scientific knowledge.

And I think, again, we're at a point where there's a need to build vigilance into the regulations so that there's periodic reassessment of doses to the public and an assessment of the international/national recommendations on exposure, and then those need to be brought into some regulatory framework to perhaps adjust the allowable public dose in one direction or another.

CHAIRMAN RYAN: I was going to sneak in one more that I forgot to ask you, Tom, and that was when Dave was talking earlier we talked about background radiation in the United States, and of course, anybody that know NCRP reports has that one pretty well thumbed through.

Is there a plan to update that report? And you mentioned a committee, and can you give us a little bit more information there?

DR. TENFORDE: Yes. This committee that is updating not only Report 93, but the information that was contained in four other reports published in the 1980s has give main components. Medical exposure, a very large team with representatives of organizations that have large databases, like ACR, for example.

Then natural background radiation, including cosmic, terrestrial and radon exposures. That also is a large team, people like Dan Strom and Alan Birchall and Dave Brenner and people who have thought deeply about radon dosimetry because, I mean, I've been aware for some years of the change in risk coefficients, and Dave has very nicely quantified what the impact is. There's almost a decrease of 40 percent in the estimated annual dose of a member of the public, and we need to get our arms around that.

And then there is a team looking at industrial sources, including nuclear power, another team looking at consumer products.

And one thing that I might mention is Report 93 backed out of any firm estimates on radiation from cigarette smoking. As you know, there's exposure to Plutonium 210 and Lead 210, and they felt at the time they were doing the report 20 years ago they didn't have enough data, and I don't agree with that because I'm aware of a lot of older data, and I want this new team to estimate the radiation exposure from cigarette smoking and maybe even take a look at the decline, another good argument for people to quit smoking, I guess.

And then let's see. We covered industrial, medical, natural background, consumer products, and --

PARTICIPANT: Internally deposited --

DR. TENFORDE: No, no. That's not separate. Industrial, occupational, background -- oh, I think I covered it. I didn't realized I had named five. It's industrial, occupational, medical, background, and consumer products.

And so we've got three dozen people hard at work starting at the first meeting next month, and we hope in three years to get our arms around these, and not only estimate mean values of exposure from all of these sources, but to look at the range of exposures.

CHAIRMAN RYAN: Are you looking at one big report or five individual reports?

DR. TENFORDE: I think we're looking at one big report. Should there be a reason to do so, I wouldn't have any problem with breaking it into some smaller reports, but I'd like to have it all in one place.

CHAIRMAN RYAN: Sure. Well, thanks for the update. That's helpful to get your insights there.

Ruth.

MS. WEINER: thanks for a very illuminating discussion. I have to say that between you and Dr. Moeller this has been one of the most informative and illuminating presentations that I've had. Both of them were.

DR. TENFORDE: Thank you.

MS. WEINER: I'd like to do back to this slide, and I would assume that to bring your third bullet into play, it says if necessary for regulatory control of public exposures, then in my mind I translate that to meaning if you do an appropriate performance assessment, you find that you do violate the first bullet.

Is that what you had in mind, that if a performance assessment carried out to a million years, let's say, brings your public dose above a quarter of a millisievert, that you then bring the third bullet into play because you can't make it on the first one, or what criteria do you impose that you translate from the phrase "if necessary for regulatory control"?

DR. TENFORDE: Well, I was waffling a little bit there because I'm not really a fan of this three and a half millisieverts, as you may have assessed. Really my main point is the second one, that there needs to be an evolution of guidance that's in step with science driven national consensus guidelines.

Should for some reason these guidelines rise to a higher acceptable level, I really feel this is not an unreasonable ceiling to put on exposure of any individual. We can look at the lifetime risk. You're starting to approach one percent fatal cancer significant genetic disease.

And the other thing that could happen, and

I put a little wiggle room in here because I'm sure that this is on the minds of the EPA people, is that sociopolitical issues may be very dominant at some point in terms of regulating public exposure. I mean at some point if the level of radiation rises and you do what I said on an earlier slide of taking remedial measures like increasing the exclusion zone or avoiding the consumption of contaminated water, then pretty soon you may have a nonhabitable area that's rather large, and at that point, social and political processes come into play and say, "Well, what can we live with," and under those conditions it may be necessary to say, "Well, I realize we're only supposed to have exposure at, let's say, 50 millirem a year based on our consensus guidance, but people are getting more than that or they will soon get more than that. What can we allow?"

And so then you have the regulatory agencies and the public and all of the stakeholders coming together trying to decide what might be acceptable, and that might be a higher number. It could be 350 millirem.

I don't think that a median dose of 350 millirem is reasonable at all, but I could see it as a ceiling on what might be collectively decided as an acceptable level above and beyond the agreed upon consensus dose standard.

So that's where I'm going on that, and I didn't explain it very much because, well, it would have taken a lot of slides, and I'm still thinking myself on this.

MS. WEINER: Well, without harping too long on it, we're in 2006 now, and we project these doses using performance assessment. So let us just suppose that we have a realization in performance assessment, one or more realizations, perhaps not a very likely one, but nonetheless that where the public dose limit of .25 millisievert would be exceeded. Would you, just for your personal estimate, would you then say, "Okay. This is an unacceptable site," or would you say, "Well, we can consider a larger dose"?

How would you handle that situation?

DR. TENFORDE: Well, you might then be in a situation where you have to look at several alternatives. One is under 40 CFR 197, there's a very carefully prescribed area in terms of numbers of acres that are the controlled site. You may have to relax that, go down to Lathrop Pond or whatever, and you may also then have to put some very rigorous measures in place to handle contaminated groundwater.

You know, there are a lot of examples of that. The mining industry has had to deal with that for years. The so-called Berkeley mines up in Montana, you know, they were mineral mines that they flooded with water and tried to recover minerals and, you know, heavily contaminated a lot of water supply around there, and now they are using electrochemical techniques to recover all of those things.

So, you know, there may be ways of introducing cautionary measures to maintain high water quality over a long period of time. Of course, these will be built and used in generations far beyond us, you know, but I mean, they're not inconceivable. I mean the public is always going to try to protect itself in my view, and if there is some guidance that this should be the plan, then I think you could use it.

And if you run all of the scenarios and you decide that these measures, these cautionary measures simply are not enough, then I think what's needed is this collective government-public process to decide what is acceptable. And you know, you have to put hard numbers on the table. You can look at this and it's, you know, five times ten to the minus five per millisievert annual risk. You can multiply that out for, say, a 70-year lifetime, and you come up with about a percent lifetime risk.

Will the public accept that? I don't know.

And so I guess my answer as best I understand it, which is an evolving process for me, is twofold. One is that you can build cautionary steps into the regulations that would diminish public exposure certainly. The other would be then if you're going to still exceed what you might expect to be the consensus guidance limit, say, 25 millirem, then engage this collective group from public, state, federal regulators, and you know, try to reach some agreed upon intermediate position that people can buy into.

I don't know how else to do it. I mean, EPA has done this. They've done this very nicely with some of the decommissioned nuclear sites. West Valley is a wonderful example where the public and other stakeholders were engaged in deciding on what the clean-up targets are.

So, you know, I think the public will be open to the idea. In fact, they welcome the opportunity to participate.

CHAIRMAN RYAN: Ruth, in the interest of

time, I'm going to ask that we defer any additional question to the round table portion of our meeting. We have two other speakers, and I want to give them their due time.

So I'm told that I think I said Dr. Kessler would be here this morning, but Dr. Kessler looks an awful lot like Dr. Kozak. So Dr. Matt Kozak will be standing here himself.

Now, please, take it away.

And, again, to be mindful of time, we're scheduled to take a short break in about an hour. So that means you have about half of that or so to give your presentation, and I think we'll go into the break as necessary.

So fire away.

MR. KOZAK: Yes, today you'll have to imagine me a little taller, a little thinner, and a little grayer and with a beard.

MR. HINZE: Did you just describe Matt?

(Laughter.)

MR. KOZAK: No, he's a little shorter, but he's got a beard, too, and he's less gray.

I am going to try to focus my comments a little bit on primarily the future climate issues, which are the issues that come out of the EPA standard that more directly bear on Part 63. So I'm not going to be talking about the more general EPA issues as we've just heard.

I feel a little bit compelled after the last discussion just to put in my personal viewpoint, and I think that the report that we put out last year we laid out some of the waste management kind of arguments, I think. Dr. Tenforde put out some nice radiation protection arguments about what the 3.5 millisieverts mean, but when you start to look at stylization as you go into the future and things like that.

There are some logical arguments that lead you to it. I don't think it's quite in as much of an outlier as his opinion holds it to be.

I would like to acknowledge that I'm pretty much plagiarizing other people's work. You saw Professor Huber I think it was your last meeting out in Vegas, and so you see the type of quality and depth of the work that he's been doing that lead to some of the conclusions that really that I'll be presenting today and the implications for the rule and for TSPA.

The other person that has been a long time contributor to the EPA program is Stuart Childs, Dr. Stuart Childs from Kennedy-Jenks, and he is our net infiltration contributor, and of course, this is supported by John Kessler.

So what I want to address is this issue of what are the long-term climate states that ought to be considered in the rule and what we need to consider for modeling. I also would like to comment on the proposed NRC interpretation of the EPA guidance. So to the extent that I need to, I'll dabble a little bit in the EPA, but I'll try to stick with NRC issues today.

I also want to just point you, give you some finger posts in the direction of some other things that we're doing on igneous intrusion out to a million years. That new work that we've done on neptunium solubility, which has some obvious implications toward peak dose and putting all of that into some updated analyses that we've done for a million year TSPAs.

So we're starting to try to look at -- someone brought up this morning about the NRC and how they go through their risk informed decision making out past a million years. We've started to try to dabble into this to look at what some of the key things are out past 10,000.

The draft EPA guidance for the compliance assessment is to fix the climate state to avoid having to justify details of the changes in the climate state in the long term.

We agree that this is an appropriate and practical approach to addressing the NAS guidance and, again, we have the report out in which we had talked about that as a concept for dealing with some of these uncertainties.

EPA proposed that the long-term climate state should be fixed at twice the present day precipitation reflecting some type of rough concept of a long-term average.

The assumption that was talked about a little bit earlier today is that the assumption here is that the past is a mirror to the future, that past climate record can be used to drive how things are going to evolve into the future.

And the question we asked ourselves is: is this a reasonable and practical interpretation. And our conclusion based largely on some of the work that Professor Huber presented to you last time is that the future climate will be different than the past, and that , therefore, the past does not form an accurate reflection of what the future will look like.

If we set aside greenhouse gas influence for a moment, which are, as you know, from reading the newspapers tend to be relatively controversial, orbital mechanics are not, and so if we take models based solely on the insulation variations and just look at orbital mechanics and what the future climate may look like based on orbital mechanics, we have a fair amount of uncertainty on whether or not there's going to be glaciation over a considerable period of time into the future, past 10,000 years, probably.

The earliest in just personal discussions with Professor Huber, he had mentioned something on the order of 40,000 might be the first time that we might see our next glaciation purely based on orbital mechanics. That's assuming no greenhouse gas emissions.

The range of forecast values at this stage includes everything from glaciation to non-glaciation over a considerable period of time into the future, and I think these quotes here are probably related to about a 10,000 year time frame, but actually I'm not sure since I'm plagiarizing other people's work.

If we then put greenhouse gas emissions on top of that, we have to consider the long atmospheric half-life of greenhouse gas, carbon in the atmosphere. So once it gets into the atmosphere it takes a long time to get back out.

The global climate change model conclusions from anthropogenic carbon that we are looking at is -- the way he works this out as you saw previously is he takes a variety of scenarios, assumptions about what people may do in terms of producing anthropogenic carbon going into the future, and if you assume one thing, you get one future climate state history or at least a distribution of histories since it's a probabilistic calculation. If you assume a larger release you get a different suite pretty much like we do TSPAs.

You make an assumption about some forcing function and carry it forward into the future and get a distribution of results.

Some of the interesting ones to point out, one of the sort of a mid-range value for assumptions about greenhouse gas emissions is the 1,000 gigaton of carbon by year 2100, and the models currently show that that's going to delay the onset of the next glaciation out to no the order of 100,000 years or more.

Some of the higher assumptions that we could make about what people are going to do over the next hundred years or so, 5,000 gigaton carbon, and there's no probability attached to these human assumptions about what humans are going to do with anthropogenic carbon, by the way. So they're spun out just as we do. We don't try to put a probabilities to human behavior. So they're spinning out these different scenarios.

Five thousand gigaton carbon delays the onset of glaciation for at least 500,000 years. So we can conclude from that that full glaciation conditions in the future are going to be shorter and weaker than in the past. Some of the realizations and some of the scenarios show that they are not too much different, but they are still delayed compared to the past just because of orbital mechanics.

And so the predominant interglacial conditions going out into the future are likely to be both warmer and drier at Yucca Mountain, not universally across the whole world, of course.

Here's an example of some calculations. This is for the 5,000 gigaton release, and you'll see that you have a cumulative distribution function here that ranges from a fairly low probability potential if you look at the axis on the bottom, a fairly low potential probability of there being some monsoon conditions.

The majority of this is it was within an interglacial kind of condition. This whole band in here is a continuation of the interglacial out to 500,000 years.

Here is an insulation threshold for glaciation and none of the realizations get there.

One of the interesting things about this, if you accustomed to reading cumulative distribution functions is it's pretty much uniform. There's not very much distinction, and so what is the best analogue to choose within that is an interesting question that comes out of that.

There's a lot of uncertainty in this is what that's saying.

So to summarize, the climate state and the details of the transition are highly uncertain. They will be difficult if we were to impose a full climate change type of approach. They would be difficult to defend in a licensing process. So we think that the EPA solution is a good one to fix the climate which is at some steady state.

The EPA choice of the fixed climate really doesn't reflect this current emerging understanding, and this isn't necessarily even a criticism of EPA. If you look at how rapidly this field is developing, if you look at literature from five years ago, they are saying things that were quite a bit different than what they are now. This is emerging within the last couple of year even.

The doubling of present day precipitation implies that EPA believes that full glacial conditions will occur frequently. They're using the past as a mirror to the future. If you factor in the greenhouse gases, the full glacial conditions are not nearly as likely and won't be as -- they will be a fairly small proportion of the next million years.

And a lot of those interglacials are going to be dryer than the ones that we see in the current day.

So given all of those uncertainties, our conclusion is that it would probably be a better foundation for the rule to go to present day climate. We've got everything from present day or drier to something that could continue on almost indefinitely. In some of the realizations we are out of the glacial/interglacial cycling. So that is a reasonable possibility that we may not see anymore glacial cycles.

So full glacial maximum conditions will be infrequent based on current understanding. A large fraction of the next million years is likely to be similar to the current interglacial conditions. Present day climate state is going to be more implementable. We can go out and we can measure things about the current climate and the current infiltration and rainfall and so forth, which we can't do when we start speculating about what an average over the next million years would be with glacial cycling.

Now, I'll come back to that in a little bit.

Okay. So that's what we actually think would be a better foundation, would be to use current day climate, but right now, assuming that the EPA standard goes forward as it stands, we're stuck with their current assumptions on double precipitation.

So if you assume that there's double precipitation, we would like to comment. Now, these are comments more directed toward the NRC. Taking the EPA guidance up to this point, what has NRC proposed?

They've proposed to specify net infiltration values rather than the details of the precipitation, and the specification ranges 13 to 64 millimeters per year, and that's founded on an assumption of five to 20 percent of the precipitation being converted into infiltration.

First of all, we're concerned with the notion of specifying actual values in the rule, not so much from an implementability standpoint, but because our understanding of these things is going on, if there is a general scientific consensus a few years from now that we are out of the glacial cycling, then we would have to go back and fix the rule. We'd have to go back and change the numbers or it wouldn't reflect current best understanding.

So there's a concern about actually putting numbers into the rule, but if you're going to put numbers into the rule, it's probably implementable or it is implementable. It's a reasonable way to make it implementable as long as the numbers make sense.

And that's our second disagreement, is that we think that the specific range of net infiltration that are in there are not well supported.

Okay. Do going back to net infiltration estimates for Yucca Mountain based on present day climate, we've got some review of a lot of work that's been done over the years, and this is a synopsis of work that's gone on within the EPRI team during that same period, too, to take that work and interpret it and to come up with our own independent estimates.

Precipitation ranges are there. You can see them. Net infiltration ranges. The bottom line to all of that is that the percentage of precipitation is on the order of two to 8.8, nine percent of infiltration.

If we look at infiltration estimates for Yucca Mountain for the transition and glacial climates we get this table, and I don't want to go through all of them, but one of the things that stands out here is the NRC ones are consistently high. They have particularly these numbers that go up to 20 don't show up anywhere else in anybody else's estimates.

So for this case where we're looking at double present day precipitation, the upper end of the NRC proposed range doesn't, in our opinion, reflect EPA's long term climate average guidance. It reflects full glacial maximum. So we would be applying a full glacial maximum for the entire time period of the GSPA or at least for the post 10,000 years. Sorry.

We believe, based on all of the other estimates and our own independent estimate, that a more appropriate net infiltration as a percentage of --net infiltration as a percentage of precipitation is on the order of five to ten percent. So it's considerably lower than what's currently in the proposed Part 63.

We're still looking at this. We're still looking at some of the appropriate precipitation range, but one of the things that I'd like to bring out is that the approach that I mentioned earlier, the use of the current present day climate fixes some of these problems.

If we use current day climate as the basis for the rule, if we can get EPA to take current day climate as the basis for the rule, NRC wouldn't be obligated to specify actual numbers in Part 63. They could just say use a range based on current understanding of current infiltration values at Yucca Mountain, and it would be able to evolve as scientific understanding of Yucca Mountain evolved or as new data were collected or what have you.

But as it stands now, if new information is collected and it's at odds with Part 63, then you either have a compliance case based on conflicting information or you have to change the rule, and we don't want to go through anymore rule changes if we don't have to, I'm sure.

Okay. So those are our recommendations based on the climate and on the infiltration work. I'd like to just, again, put some sign posts up to where you can find some of our other recent work. We've done quite a bit over the last few months, and there's more that's coming out over the next few months.

We've done work on the igneous intrusion. We had talked last year I guess it was about the extrusive scenario. We've got a companion report on the intrusive case that I'll talk a little bit about today, but just to give you the highlight and to point you in the direction where you can get the full report.

We've gone through a major update to our TSPA model for the nominal case, really trying to look at some of these issues out past 10,000 years. We've got a new neptunium solubility report that we've imbedded into our new TSPA calculations. We went back and we updated the geosphere model. It was several years out of date, and so we went back and really looked at it, and one of the big impacts that we found was updating our Kds for thorium, in particular, was a bad actor in our TSAP, and the EBS degradation model. We've got a new EBS degradation model that we believe is a bit more realistic.

One of the things that we've tried to do very much over the last few years is to reflect a reasonable expectation philosophy. There's an error on this slide, and it actually reflects the conundrum that we find ourselves in frequently, that as performance assessors, we always fall back into a reasonable assurance mode of thinking. When we're faced with an uncertainty, we end up being conservative and we keep on trying to fight that even internally to make sure that we're trying to come up with a reasonable expectation approach, and you can see that even when I'm putting together slides, I fall back on that.

Okay. So the neptunium solubility estimates, this is based -- this is actually a work of -- predominantly the work of Professor Langmire from Colorado School of Mines who many of you probably know quite well.

There is a report completed. The Web site that you can get a PDF copy are there, but the bottom line is that the neptunium solubilities are -- reasonable expectation values for neptunium solubilities are orders of magnitude lower than what DOE is using in TSPA. My personal feeling is that they're probably looking to minimize their licensing risk by using conservative values, but it ends up having a very major impact on the post 10,000 year evaluations.

We have this updated EBS degradation model, and I don't want to go into this too much, based on work by Dr. Fraser King, who's a consultant out of Canada with a lot of years of waste management experience, and it's looking at corrosion of C22 and corrosion of the titanium drip shields.

And in contrast to what Tim McCartin said earlier this morning, our waste packages don't fail. The waste packages we find based on the corrosion science that goes into our models, that the waste packages are lasting quite well. You have to count the zeroes out here. I can see Allen leaning forward. This is a million years out here.

VICE CHAIRMAN CROFF: Commas, you can at least give us commas.

MR. KOZAK: Yeah, this is actually a million years here. So we still have some of our waste packages surviving well past a million years.

CHAIRMAN RYAN: you need to get Kessler make that a slide.

(Laughter.)

MR. KOZAK: Our revised base case TSPA, again, the details of the values and the curves are not necessarily that important, but one of the things that is important now, with the lower neptunium solubility, it's no longer the key radionuclide and the decay products are no longer the key.

The iodine and technetium come up being the worst actors out at the peak dose out at a million years.

So obviously this issue of what the appropriate neptunium solubility is a very important thing, and depending on the technical basis you choose for your neptunium solubility, you can get these orders of magnitude difference, and actually ultimately what it means is that it's going affect which of your radionuclides are key, and since they are released by different mechanisms, it's going to be very risk -- it's a very important feature for being risk informed.

And we're identifying conservatism in the EBS degradation model, and we're continuing to carry that forward.

The igneous intrusion model, here again, there is information on where you can get the full report on all of the details. Both from the EPRI team and other presenters that you've had in front of you, you've heard this idea that the eruptions are a much lower temperature, much higher viscosity, and much lower energy than what has been assumed in the past TSPAs by both DOE and NRC.

And so when you take that into account, there is relatively limited magma entry into the drifts, taking into account the cooling of gases as they move away from that magma front as it goes into the drift.

There's a relatively little impact on the number of waste packages that will fail. I don't want to get into the details of this, too much, but the bottom line is that based on that type of conceptual model of the eruption, that there are additional waste package failures, but when you weight them by the probability, the overall scenario becomes relatively unimportant compared to the nominal case.

So to summarize, best long-term climate state to use in our opinion is the present day. We have data for it. It frees up NRC to not actually specify values in the rule that can cause them issues later on, but if we continue to go forward with the currently proposed EPA rule, we think that the net infiltration range is a bit high based on what everybody else's estimates seem to be, and the reasonable -- again, making the same mistake again -- reasonable expectation approach to modeling and the recent insights that it provides us, that the igneous intrusion does not contribute significantly to the performance of the repository, and our latest TSPAs for the nominal case are showing below .1 millirem per year.

And that's all that I had for you.

CHAIRMAN RYAN: thanks. We appreciate, and I guess I'll take the other topics that you brought up in addition to the EPA standards as you're volunteering for new presentations.

MR. KOZAK: Sure.

CHAIRMAN RYAN: Great. Rather than take questions now. I'd like to ask our last speaker of the afternoon.

VICE CHAIRMAN CROFF: We don't have his slides. I have a clarification on one of them.

CHAIRMAN RYAN: Let's take it at the end because I want to make sure we have plenty of time for our speaker if you don't mind.

MR. KOZAK: Sir, you didn't have copies of it?

VICE CHAIRMAN CROFF: Yes. I'm sorry. I do.

MR. KOZAK: Oh.

CHAIRMAN RYAN: We'll take it up after the next speaker. So we can cover questions then if that's all right.

I'd like to ask Mr. Martin Malsch to come on up and make his presentation, and then we'll handle questions afterwards. I just want to make sure we have plenty of time for all speakers before we reach the ending for the day.

MR. KOZAK: Do you want this?

CHAIRMAN RYAN: Welcome, Mr. Malsch.

MR. MALSCH: I thank you very much for having me.

(Pause in proceedings for fire alarm.)

CHAIRMAN RYAN: I'm going to suggest that we maybe say "fire alarm went off."

(Whereupon, the foregoing matter went off the record at 3:03 p.m. and went back on the record at 3:06 p.m.)

CHAIRMAN RYAN: We're back on the record now. Mr. Malsch, thank you very much.

MR. MALSCH: I was going to say I hadn't planned on making any incendiary comments --

(LAUGHTER.)

MR. MALSCH: -- but now that you're all prepared, maybe I should go forward.

CHAIRMAN RYAN: It's a hard act to follow.

MR. MALSCH: Thank you very much. My name is Marty Malsch. I'm with the law firm of Egan, Fitzpatrick, Malsch & Cynkar, who represent the state of Nevada on Yucca Mountain matters.

We are still working on our NRC and EPA comments, so what I can tell you today is still very preliminary. In fact, we are only in the preliminary stages of working on our NRC comments and we are, as I speak, working on our comments to the EPA.

Let me begin with, though, some preliminary comments about what we think so far about the EPA standards and then I'll follow with a few comments about the NRC standards.

From what we've seen so far on the EPA standards, they appear to suffer from at least nine utterly fatal defects. First of all, they appear to be scientifically unfounded. To the extent that they are premised upon the belief that there are dramatic increases in their conservatisms or uncertainties after 10,000 years, we believe, that premise is unfounded. As near as we can tell, the major uncertainty is not based upon the analysis done to date, not in the magnitude of the calculated peak dose, which is what you would need to see to justify an increase in the magnitude of the standard, but rather the major uncertainty is in when the peak dose would occur, which (a) illustrates the wisdom of the National Academy of recommendations that the standard be focused on the peak dose whenever it occurs, and (b) illustrates the arbitrary nature of any standard that increases in a step-wide fashion at any particular time.

Two, we think it's contradicted by the Coen Report itself, which we think does not support the EPA's conclusions about uncertainties or conservatism.

Three, it's completely illogical. After premising the selection of 350 millirem on various uncertainties, most notably climate change uncertainties after 10,000 years and uncertainties in specifying so-called BEPPS after 10,000 years, EPA then proceeds to undercut the very basis for its own recommendation by specifying climate states and specifying BEPPS. So the rule is internally inconsistent.

Fourth, it's inconsistent with established NRC and EPA policies with no rational explanation, is inconsistent with prior treatments of the relevance of background in establishing acceptable levels of risk. It is inconsistent with prior EPA statements about strict intergenerational equity, and it is inconsistent with prior EPA statements and treatment of uncertainty. In all prior locations in which we've been able to examine, uncertainty had led to either the use of enveloping assumptions or to the use of more stringent standards, not in the use of less stringent standards.

Fifth, the standard appears to be in violation of international law. There is an international convention to which 30 or more countries, including the U.S., have subscribed. That convention adopts a rather strict principle of intergenerational equity which this EPA rule rejects.

Sixth, it's beyond EPA standards -- EPA's authority to set standards in two respects. First, it is an unnecessary and unlawful intrusion into NRC's licensing function and, two, to the extent that we can tell, it is actually not a health-based standard, which it is supposed to be.

Next, it is contrary to well-established principles of ethics and morality, that at this point, both NRC and EPA have espoused. This is an especially interesting topic for us, and we have actually engaged the services of a nationally recognized ethical scholar to comment upon the EPA rule and, while her report is still in the various stages of preparation, she has provided us with some very interesting insights on how EPISIS view intergenerational equity.

There is apparently a point of view among some in the ethical community that would say that since we cannot possibly imagine what future human beings or future generations would be like, that it follows therefore that we have no ethical duty to this and future generations. While that is a view which some espouse, it is, if you think about it, contrary to the NES recommendation and contrary to the concept that we should have a standard to focus upon those whenever it occurs because, after all, if after a certain point, we know unknown duty to a future generation, at that point, there should be no standard.

However, once you accept that there is a -- some principle of duty, some duty that we do owe to future generations, knowing, as Edward supposed, as near as we can tell, that one's duty to a --

(FIRE ALARM DRILL.)

MR. MALSCH: No one who believes that they do owe a duty to future generations has ever supposed that the nature of that duty depends upon one's birthday. One's birthday has never been considered to be a relevant factor.

Now, some people think when the trade off, the public health and safety needs of the current generation, as against social economic needs of other generations, and people have also wondered about the ethical dilemma that is posed if you -- if we have a situation where we are trading off between a health and safety interest of a future generation and the health and safety interests of the current generation, that situation poses a classical ethical dilemma. The difficulty we have, assuming we assume that that dilemma is posed by establishing standards for Yucca Mountain, the problem with the rule making is EPA hasn't identified what the trade-off is. It's not possible to comment intelligently about a trade-off unless we know what the trade-off is. On the future generation side, you know the trade-off is an incremented risk beyond -- above and beyond what we would consider ourselves acceptable today. But we don't know what the benefit or risk is to the current generation that we're trading off. EPA doesn't identify it in the rule.

One has the suspicion that we're talking about the risk associated with no Yucca Mountain, but if that were the case, the world would be completely circular. If it's not another Yucca Mountain, then EPA has not identified what the trade-off is and it's impossible to comment intelligently upon any kind of a trade-off. The rule making becomes completely defective.

Another fascinating thing, which is discussed in the EPA rule making, is the concept of a rolling presence in which each generation sort of engages in the kind of reevaluation of its ethical principles and duties to future generations. That was an especially interesting thing for the EPA to suggest because along with that suggestion comes, necessarily, the institutional mechanisms to accomplish such a trade-off. EPA's rule does not postulate the existence of any such mechanism and, in any event, you'd probably just see how it would be relevant once the repository is closed and we are more or less committed to whatever consequences there will be.

Lastly, -- well, next to lastly, is contrary to the recommendations of the National Academy of Sciences. This is most particularly obvious when we see that the EPA has recommended use of the median as a measure for compliance and the NES specifically recommended use of the means.

And finally, I think we can see that the rule is in danger of complete collapse when it is actually applied. What will happen, for example, if when the rule is applied, it turns out that the total system performance assessment upon which the LA relied, or upon which the Commission relies for licensing, contains none of the uncertainties or conservatisms on which the EPA relies.

In an early meeting with EPA, we warned EPA about the dangers of establishing a rule that was premised upon a particular snapshot of the DOE Federal Assistance Performance Assessment as it existed at that point in time and pointed out to them that if in licensing the PSGA is in any respect different, then the basis for the rule collapses. They seem to have rejected our advice.

As a sort of aside, it seems to me, just speaking personally here, that it's a sad day for nuclear power when a federal Agency actually believes that the price for nuclear power is a diminished duty, ethical duty of the future generations, and I would question whether Yucca Mountain is really worth that price.

From Nevada's perspective, the rule is so over the top that it illustrates the extreme and unprecedented measures the proponents of Yucca are prepared to go to, thus, to a doomed project.

We would predict that when all the comments are in, the EPA proposal will look like New Orleans after Katrina. The EPA and the real moving force behind the real DOE will look even worse than FEMA.

Although EPA is here to have played some, as yet undefined, role --

(FIRE ALARM DRILL CONTINUES.)

MR. MALSCH: Although NRC appears to have played some undefined rule in developing the EPA proposal, and NRRC has actually not, in the past, shied from publicly criticizing EPA rule-making proposals, the staff appears to be in a mode whereby the theory seems to be if you can't say anything good about the EPA rules, don't say anything about it at all.

In any event, with this premise in mind, though, let me proceed to make a few comments about the NRC rule. As I said, we're just now working on the EPA comments. We do have a few preliminary observations or really, I guess, what I should say is a few sort of preliminary questions.

The first question I would ask about the NRC rule is, has the Commission failed to implement an important EPA recommendation? EPA stated in its proposal that, "NRC has the authority to consider not only the magnitude of the peak, but also the timing and overall trends of those projections as it evaluates the license application." Where is this in the NRC rules? One has the impression that NRC will find post-closure performance acceptable based solely on whether the peak dose meets the EPA standards. Or is it NRC's opinion that the EPA rule is a necessary, but not sufficient, basis for dose closure safety?

I heard Dr. Kotra speak earlier about how they might be examining not only the median, but also the means. This suggests that it is NRC's view that the EPA standard is, indeed, a necessary condition for licensing, but not a sufficient condition for licensing. If that's the case, I think the rule should say so specifically.

Second, why is NRC proposing to specify climate states specification and invocation rates in its rule and thereby preclude these things from being questioned in the staff review or licensing hearing?

Now, true, EPA says in its proposal that NRC shall specify in regulation the values to be used to represent climate states, climate change, such as temperature, precipitation, or infiltration rates.

But why isn't this a clear intrusion of NRC's licensing function? In the past -- and I can give you examples of this -- in the past, NRC has objected strenuously to EPA proposals of this sort that intrude upon NRC's licensing implementation function. Why isn't NRC objecting here? After all, an EPA direction to NRC to do a rule is not itself a rule. This is not a standard that's being implemented. This is simply a bare instruction. So it's not the sort of thing NRC is obligated to implement.

It also blurs the classic legal distinction between what is appropriate for rule making which is generalized findings of fact that are not cite-specific and un-use of policy as opposed to findings of adjudicatory facts. The sort of things that are typically appropriate only for individual licensing cases.

Why aren't these things appropriate for the licensing views and licensing cases? Why are we specifying not that rule?

Our experts are telling us preliminarily that using, for example, steady, safe precipitation is not appropriate, that doing so may mask important affects that vary year to year, and that may underestimate infiltration and clear estimates in infiltration are highly uncertain, that the models may be inadequate, that the models have been criticized in the past by NRC's own experts, that some of the data may have been overlooked, that future climate states may affect changes in soils and vegetation and may need to be considered.

(FIRE ALARM DRILL ENDED.)

MR. MALSCH: And that there may be no basis to limit the effects of climate change to increase flow to the repository.

Now our final views will be in our comments, but this raises a very fundamental question, like I think was also raised by the EPRI comments. Is the state of knowledge of future climate states, infiltration rates, and the like so complete, and the results so conclusive that they must be eliminated from any further review and licensing years before the license application is even filed? What if the results of new studies undertaken in the aftermath of the US/DS scandal, show the NRC is wrong or that EPA is wrong?

We know that NRC and DOE calculations so far did not include the effects of global warming and that models are being developed in Europe and elsewhere that could be used to project the effects of global warming in the southwestern United States. Why not wait?

In one, EPA has suggested -- EPRI has suggested, for example, that there is an emerging understanding in this field and that, for example, infiltration rates may not be suitable for specification by rule-making because they would preclude consideration of the results of emerging science.

Why are EPA and NRC so afraid to consider these things in licensing? Why are they insisting that now, at a very preliminary stage, that it is specified by rule?

In terms of intrusion on the NRC licensing process, how far will this EPA incursion in the licensing process go? Would NRC have to comply with an EPA rule tied in to abolish all QA requirements or imposing the draconian new QA requirements? Would NRC have to comply with an EPA direction to forget about natural analogue? Would NRC have to comply with an EPA direction to assume that all the contents of waste packages are released immediately when the first drop of water penetrates the cladding? And how is it EPA's role to tell us now, definitely, after only a few month's effort and no peer review whatsoever, the

DOE's performance assessment for the pre-10,000 year period is sufficient scientifically for projecting performance after 10,000 years?

Besides, you and your staff have undoubtedly talked to some of the very pleasant EPA people who have always been very aware of this rule. Did you get any sense of confidence that they knew enough about the CDSA to be making definitive judgments of this sort? Are you aware, for example, that EPA originally proposed, quite sensibly, that in some depth might manifest themselves only after 10,000 years, that the NRC should have broad discretion to include additional steps in the post-10,000 year performance assessment period if they would significantly increase peak dose. This matches exactly NRC's proper role in implementing an EPA dose standard. However, OMB apparently made EPA delete this from the final proposal. Of course, OMB doesn't know anything at all about high-level performance assessments, so one can imagine the source of this recommendation is probably DOE. Who knows what NRC's role was in all of this, but it basically illustrates the dangers of intruding on NRC's licensing function and specifying things by rule when really it is premature to do so.

Finally, one last comment about the EPA rule. What on earth is the intended effect of EPA's proposed 10(c) FAR 66.114(b)? This says that the post-10,000 year performance assessment must be based upon performance assessment specified in Paragraph (a), which is the pre-10,000 year performance assessment. And we already see in a separate provision of the NRC rule provisions that limit post-10,000 year performance assessment steps that specify how indigenous and stein and seismic vents are to be Considered, to specify how climate change is to be considered and specify that general corrosion to be considered. What additional limitations does 66.114 (b) impose? We have no idea and we can't tell.

In the end, we hope that in the final analysis, NRC will decline the EPA's invitation to pre-judge technical issues that are more appropriately a part of the NRC licensing process and reassert its role to judge the adequacy of the DOE sole system performance assessment.

That pretty much concludes what I have to say here today. I'm happy to answer any questions you have, although I've indicated these are very preliminary comments, we're still working on the EPA comments, and we're just beginning to work on our NRC comments.

Thank you.

CHAIRMAN RYAN: Thank you. I guess perhaps we ought to get them back up and we'll take any questions for our last two speakers as they come up. We'll start with any questions for Mr. Malsch?

(NO RESPONSE.)

CHAIRMAN RYAN: I'll get to you. Ruth?

MS. WEINER: This is a hypothetical question, and I'm always nervous asking lawyers questions.

MR. MALSCH: Oh, lawyers love hypothetical questions. We may not just answer them, though.

MS. WEINER: Could anybody have come up with a rule that you would have approved of?

MR. MALSCH: Yes, we proposed one. We proposed simply extending the 15 millirem standard out to --

MS. WEINER: So if EPA had simply done nothing else, extend no direction to NRC, to just extend to the 15 millirem per year dose out to infinity or a million years or whatever, you would have said "great, we approve of it?"

MR. MALSCH: We actually told EPA that in our meetings before they published the proposed rule.

MS. WEINER: Thanks.

MR. MALSCH: We thought that was the simplest, most straightforward application of the core decisions and NAS recommendations.

MS. WEINER: Well, it's nice to know you did have something in the line.

CHAIRMAN RYAN: None from Alan. Bill?

MR. HINZE: Briefly. The state of Nevada has no problem with having essentially a time of compliance of one million years, without assurance that that reaches a peak dose?

MR. MALSCH: Well, we were just assuming that a million years approximated the geologic stability. I don't think we've looked any further into it. I think we just made that assumption so far.

MR. HINZE: So essentially, you fabricated the concern regarding the peak dose and as long as it's a million years, that's fine with you, despite the fact that this is not what the National Academy Committee said, stated?

MR. MALSCH: Well, they said peak dose, we were in a period of geologic stability and there was an aside that said that appeared to be on the order of a million years. Frankly, we've not actually evaluated whether that was a valid assumption or not.

We just assumed it was true.

MR. HINZE: Thank you.

CHAIRMAN RYAN: Michael Lee, do you have a question?

MR. LEE: It's just more a point of clarification. The Committee was not involved in the OMB review process and EPA declined an opportunity to speak to the Committee publicly or privately, for that matter. So, we're --

CHAIRMAN RYAN: We're reading the Federal Register.

MR. MALSCH: Yeah. Just also for clarification, my remarks about what OMB did are available in the EPA docket because the EPA docket includes what is apparently the OMB mark-up of the EPA proposed rule, and that mark-up shows the deletion of the invitation to NRC to specify additional steps.

CHAIRMAN RYAN: Thank you for that reference. That will be helpful.

Again, I apologize for the fire alarm. I know it's not something I can control, but I appreciate your patience and everybody's attention to your comments.

Just in closing, I'd like to mention that we heard this morning that we're going to have a follow-up briefing from NRC staff in December, and I think we'll be working on perhaps other follow-up briefings and would welcome any further comments you might have. As you finalize your comments, we welcome you back to provide those to the Committee in a more formal forum, if you like.

MR. MALSCH: Yeah, I'd --

CHAIRMAN RYAN: At the December or a future meeting that's appropriate.

MR. MALSCH: Yeah. I'm sure we'd be happy to do that. As I said, we've not just assembled our comments based upon what a bunch of lawyers think about the rule in a room. We've actually engaged technical experts to comment on the technical aspects of this.

CHAIRMAN RYAN: And, again, hopefully, we won't have a fire alarm during that next presentation. But thank you very much for your patience and your presentation today.

MR. MALSCH: Thank you.

CHAIRMAN RYAN: Are there any further questions for Mr. Malsch?

(NO RESPONSE.)

CHAIRMAN RYAN: And I welcome you to stay to add any other comments.

If not, are there any questions for Dr. Kozak? Allen, you had a comment?

MR. CROFF: I had -- well, a couple of questions. My clarification question, just to get it on the record, Matt, it had to do with his Slide 16, which is the updated engineering barrier system degradation model, and there was a legend at the side going with the curves with things like "DSWP," et cetera. And I was wondering what those stood for. And I guess -- do you want to run through them?

DR. KOZAK: Yeah, if we could. Maybe just briefly. They're individual components either of the waste package or of other elements of the EBS. So, yeah, "WP" is waste package. "DS" is drift shield. The ones with "Ls" in them relate to localized corrosion at the lid, so it's outer lid, middle lid -- to be honest, I'd have to go back and look at the report. I'm congenitally incapable of retaining acronyms.

(LAUGHTER.)

MR. CROFF: And a second question of maybe some more substance, on the next slide, your TSB Base Case goes off to a million years, but has not peaked yet.

DR. KOZAK: And to a large extent, that is a function of the engineered barrier system. We get a lot of credit from the engineered barrier system, but in point of fact, all that does is shift things out to later times. It doesn't change the peak very much. If you can spread it out over a long period of time, but it -- it doesn't actually do that. It -- we get longevity, but we don't get a spreading of the failures.

MR. CROFF: It doesn't change the magnitude of the peak, just the timing of it?

DR. KOZAK: Yes.

MR. CROFF: When is the peak? It runs off the end of the curve here.

DR. KOZAK: We have run it out and it's not too much further out than a million years.

MR. CROFF: How about up?

DR. KOZAK: It doesn't go up much higher at all.

MR. CROFF: So it doesn't reach down to minus one?

DR. KOZAK: No.

MR. CROFF: Okay.

CHAIRMAN RYAN: Again, I think -- thinking ahead of that, simply if we do get into more detailed presentations on that, clearly we'll need to know where the peak is, both in terms of magnitude and time to help understand the question a little bit.

Thank you.

Are there any other questions? Are you all set, Allen?

MR. CROFF: Yes.

CHAIRMAN RYAN: Bill?

MR. HINZE: Just a brief question. You related the duration between -- the period of time between glacial cycles to the intensity of the glacial activity, if I understood you correctly, that because of a long duration, is the same factors would lead to a lower intensity of the glacial activity. I was -- I am unaware of any evidence for that.

DR. KOZAK: I don't think I was intending to link them. It was just a statement that because the overall -- because of the overall warming that if the glacials do occur, that they are not deep. That the -- my understanding of it, and this is Professor Huber's expertise, obviously, but that -- because the overall insulation rate is higher, that then the depth is not -- the intensity --

MR. HINZE: I think that he had an argument regarding that because during some of the warming periods, some of the glacial cycles -- some of the cooling cycles have been extreme.

DR. KOZAK: Yes.

MR. HINZE: Very rapid and quite extreme. So I think we have to be a little careful about extrapolating the work that Matt has done too far into intensities.

DR. KOZAK: Agreed. He's seen those slides. I didn't do these in the absence of him.

CHAIRMAN RYAN: Thanks. Jim?

MR. CLARKE: Just to clarify a matter. When you say "net infiltration --

CHAIRMAN RYAN: Use the microphone, please, Jim.

MR. CLARKE: When you say "net infiltration," that's what other people call "deep percolation?" That's --

DR. KOZAK: Yeah.

MR. CLARKE: -- the water that could reach the depository?

DR. KOZAK: Yeah. Yeah, that's right.

MR. CLARKE: And also, on your igneous event, damaged waste packages are damaged in the sense that they're potential sources due to subsurface, but not to the atmosphere, is that right?

DR. KOZAK: That is correct because for

them to be sources to the atmosphere, they have to be in the conduit after the formation. The ones that -- I didn't go into the detail, but we broke it down into several zones. You have ones that are essentially -- waste packages that are essentially embedded in the salt afterwards. So after things have cooled back down, they're embedded in the salt. And then you would have ones that may be partly contacted and then if it doesn't flow all the way down to the end of the drifts, you would have a third area that's only contacted by hot gasses. And we have different failure functions for each of those. The predominant failures are in the second zone. In other words, the ones that are embedded, you have additional effects that tend to preserve the waste package because you have counter-pressure and things like that. But if you have -- if you have the magma flowing down the drift and it only reaches halfway down a waste package, that's sort of a worst case, where you have internal pressurization; you don't have the counter-pressure on it and it can pop the lid a little bit. But that's the type of failures that we'd be looking for.

MR. CLARKE: If I understand your results, you're not predicting any release in the ash of radionuclides, is that right?

DR. KOZAK: For the extrusive case, that is correct. Our expectation case was that there would be no releases. So this is -- these are ones that would be outside of the conduit, but they may suffer some damage because of the heat and chemical effects.

MR. MALSCH: Mr. Chairman, I wanted to -- I forgot to give you two references I thought you might be interested in. For an official NRC position about the proper role of EPA vis-à-vis NRC in the waste area and for, in fact, a statement of position that resembles almost exactly the position of the state of Nevada here today, let me refer you to two documents on the LSN and these are letters from NRC to EPA and Commission papers. One is -- I'll just give you the numbers and you can have your staff look them up. They are NRC000024461, that's NRC000024461, and NRC000024406. The second one is NRC000024406.

CHAIRMAN RYAN: Okay. Thank you very much.

MS. WEINER: This is for Matt, who is clearly busily writing something down. On your Slide 12, where you showed all the different net filtration rates and precipitation rates. To what do you attribute the fairly large range in infiltration rates that is predicted? Is there some general overall thing or is it a different thing for each rate?

DR. KOZAK: I think it's a different thing for each rate. They're all different. They're different studies done by different methods. Some of them are modeling; some of them are experimental. So I think it's just --

MS. WEINER: Is there a way that you could identify the experimental ones or the modeling ones? Is there a trend that you can, or are the experimental ones always bigger, smaller, whatever?

DR. KOZAK: I'll take that under advisement. This is still in progress, this work. I can take that back to Stewart and see if he can do the correlation.

MS. WEINER: That would be very helpful. I tend to kind of understand experimental things more than just modeling things and it would really be interesting for us --

DR. KOZAK: Yeah, sure.

MS. WEINER: -- to see that. My other question is kind of -- depends on a paper that I heard just recently. Do your estimates of carbon dioxide emissions include emissions, the projections of greatly increased $CO_2$ emissions, coal burning from

India and China? Because I heard a paper just a couple of days ago that looked at these enormous increases and could swamp anything we do.

DR. KOZAK: I'm not sure. I'd have to go back to Professor Huber and find out what the basis are for the different values. He's part of -- he's heavily involved in the IPCCs, so I'm sure they're involved with all those things. They're probably the same people publishing the reports, I would guess.

MS. WEINER: Thank you.

CHAIRMAN RYAN: Again, thinking ahead a bit to perhaps December and beyond, as we get our arms around some of the technical aspects of the proposed standard and the EPA standard both. Getting a handle on risk significant issues, I think, is going to be a task that we'll probably all have in front of us, and us in particular, to think about what's important and why in terms of risk. And that is the question of the dose and its magnitude, the dose and its temporal location because that has an impact on what radionuclides might contribute and so forth, and some of these issues that now you've talked about today of infiltration rates and it's rightly commented on, what's experimental and what's calculated and what's a model and what's not a model, and those kinds of things. And I think as we move ahead, any insights you can share on risk insights that are really in that realm, not a reasonable assurance, but reasonable expectation of going and correcting itself, that's an essential element of this discussion, I think, to really get at what are reasonable expectations and why and what is risk significant and why. And then some focus on, I guess, equally as important, what is not risk significant and why. And then we can sort of begin this process of sorting out this timeframe from kind of the fourth to kind of the sixth years a little bit better. So I just offer that comment to everybody that as we think about presentations down the line and what will be helpful to us as we formulate our advice to the Commission, that any insights you can bring back with that in mind would be helpful. Dr. Huber's climate work, for example, I think he was asked this question. I may not have it just right, about the uncertainty in some of his modeling and he said, oh the models are very well known, as if they were fact, true, you know. So the uncertainty aspect of those, of course, I think we all accept the fact that a global multi thousands of years carbon model or temperature model probably has some uncertainty with it.

MR. HINZE: I think he also went on to say that the data wasn't that certain. The models might have been, but the data wasn't.

CHAIRMAN RYAN: My own definition as a model is often challenged by the quality of the worst piece of data in it.

MR. HINZE: Amen.

CHAIRMAN RYAN: Again, it's that perspective of certainty and uncertainty that I think we would ask that people do their best in addressing in future presentations because that will be a help to us.

Are there any other questions or comments? I'd invite our other speakers from your earlier, Dr. Waller or Dr. Penfoyer, if you'd have any other comments you'd like to make, please feel free to do so.

John, you had a question?

MR. FLACK: Well, yeah. I think --

CHAIRMAN RYAN: And, again, if you'd just help the Reporter and tell us who you are again.

MR. FLACK: Sure. This is John Flack, ACNW staff. Just to follow-up on your comment about -- question about what's risk significant. I'm looking at this chart on Page 16 about the degradation model and --

CHAIRMANY RYAN: This is from Dr. Kozak's presentation?

MR. FLACK: Yeah. And it says that removing these conservatisms really has a substantial impact on the time when these packages degrade and I would then question what are these conservatisms because they would certainly would be risk significant because they're really affecting the calculi -- I mean just from that chart, it's -- it really comes across, so maybe if -- I don't know if you could go through those conservatisms that were removed that made these packages last so much longer?

DR. KOZAK: I will attempt to, but I'm not a corrosion expert.

CHAIRMAN RYAN: Rather than do that at this point, I would request that we ask you to take that question back and that we have a presentation on it very specifically because it is, as John's pointed out, an eye-catcher and that's why I invited -- I took all those as volunteering to come back for more presentations so we can understand the details of those issues.

DR. KOZAK: Quite right. And the details of those -- of the corrosion model are in our end of the year report, which is not in the list that you've got in front of you now because it's not done yet.

CHAIRMAN RYAN: Okay. Well, we'll --

DR. KOZAK: But it will be in the near future.

CHAIRMAN RYAN: -- look forward to that. Okay, great.

MR. HINZE: Could you give us a heads-up on that?

DR. KOZAK: Absolutely.

MR. HINZE: So the staff, you know, will have it.

DR. KOZAK: Sure.

CHAIRMAN RYAN: Latif, yes, please?

MR. HAMDAN: I have a question for Tom Tenforde. Thank you for your interpretation. I just have one question. When did the NCRB or you personally give comments on the EPA proposed rule to the EPA and, if not, why not? You seem to have very good comments.

DR. TENFORDE: Well, thank you. I'm encouraged to take a little time to try to write my thoughts down in a narrative form and I'll do my best to do that on time. I believe the deadline is a couple of weeks down the road, isn't it? What is the

-- well, we've got that from the package of information, so I'll try to meet the deadline. Thank you.

CHAIRMAN RYAN: Is there anything else?

(NO RESPONSE.)

CHAIRMAN RYAN: Well, we'll take our 15-minute break and reconvene at 4:00 p.m. Again, thank you all. We'll see you in 15 minutes.

(Whereupon, the above-entitled matter went off the record at 3:44 p.m. and resumed at 4:08 p.m.)

CHAIRMAN RYAN: At this point, Mike, we're just going to do letter writing. Do we need to have the Reporter?

MR. SCOTT: No.

CHAIRMAN RYAN: We do not. So I guess we'll end. We're not having any new input. So we'll end the official transcript at this point and we'll move on to letter writing.

(Whereupon, the above-entitled matter was concluded.)

## CERTIFICATE

This is to certify that the attached proceedings before the United States Nuclear Regulatory Commission in the matter of:

Name of Proceeding: Advisory Committee on Nuclear Waste 165th Meeting

Docket Number: n/a

Location: Rockville, MD

were held as herein appears, and that this is the original transcript thereof for the file of the United States Nuclear Regulatory Commission taken by me and, thereafter reduced to typewriting by me or under the direction of the court reporting company, and that the transcript is a true and accurate record of the foregoing proceedings.

Lindsay Barnes
Official Reporter
Neal R. Gross & Co., Inc.

## EPA PROPOSED YUCCA MOUNTAIN STANDARDS

Dade W. Moeller, Ph.D., CHP
Professor Emeritus
Harvard University
Chairman of the Board
Dade Moeller & Associates

257 River Island Road,
New Bern, NC 28562
Telephone: [252] 633-3352
E-mail: dademoeller@cconnect.net

1

## EPA PROPOSED YUCCA MOUNTAIN STANDARDS*

REVIEW, EVALUATION, AND INDEPENDENT ASSESSMENT

2

## EPA PROPOSED YUCCA MOUNTAIN STANDARDS

OBJECTIVE

To Provide Scientific Data for the Establishment of a Dose Rate Limit for the Time Period Between $10^4$ to $10^6$ Years After Repository Closure "to Ensure That Releases from Yucca Mountain Will Not Cause Exposures to the RMEI to Exceed Natural Background Levels With Which Other Populations Live Routinely" [USEPA, 2005, page 49037, middle column]

3

## EPA PROPOSED YUCCA MOUNTAIN STANDARDS

REFERENCE

USEPA, "Environmental Protection Agency, 40 CFR Part 197, Public Health and Environmental Radiation Protection Standards for Yucca Mountain, Nevada, Proposed Rule," Federal Register, Vol. 79, No. 161 [August 22, 2005].

Accessible at:
http://www.epa.gov/radiation/yucca

4

## EPA PROPOSED YUCCA MOUNTAIN STANDARDS*

BASIS

This was in Accord with a Long-Standing Recommendation of the International Commission on Radiological Protection [ICRP, 2004, Section 6.1, §157, page 41]

The ICRP "considers that the annual effective dose from natural radiation sources, and its variation from place to place, is of relevance in deciding the levels of maximum constraints that it now recommends."

5

## EPA PROPOSED YUCCA MOUNTAIN STANDARDS*

REFERENCE

ICRP, "2005 Recommendations of the International Commission on Radiological Protection – Draft for Consultation" [2004]. Available at:
www.icrp.org

6

## EPA PROPOSED YUCCA MOUNTAIN STANDARDS

BASIS

The ICRP has Also Stated [ICRP, 1991, §(190), page 44] That:

Although natural background may not be welcome, "the variations from place to place [excluding the large variations in the dose from radon in dwellings] can hardly be called unacceptable."

7

## EPA PROPOSED YUCCA MOUNTAIN STANDARDS

REFERENCE

ICRP, "1990 Recommendations of the International Commission on Radiological Protection," Publication 60, [1991, §(190), pages 44-45]

8

## USEPA APPROACH

NATURAL BACKGROUND

For Purposes of the USEPA Assessment, Natural Background was Defined as:

"External Exposures from Cosmic and Terrestrial Sources, and Internal Exposures to Naturally-Occurring Radon" [USEPA, 2005, page 49037, left column]

9

## USEPA APPROACH

USEPA REFERENCE DOCUMENT:

Serving as a Basic Source of Data for the USEPA Proposed Rule Were the Dose Rate Estimates in the Following Report:

"Assessment of Variations in Radiation Exposure in the United States" [July, 2005]

Prepared by Mauro, John, and Briggs, Nicole M.
S. Cohen & Associates
McLean, VA

10

## USEPA APPROACH

Includes Evaluation of Dose Rates due to:

*Indoor* Cosmic and Terrestrial Radiation, and *Indoor* Radon*

*Radon Concentrations Were Based on USEPA, National Radon Database, Vol. 6, National Residential Radon Survey, Report EPA-R-93-013 [1993]. All Data Were for State-Wide Averages.

11

## COMMENTARY

OMISSIONS

[1] Outdoor Dose Rates from Cosmic and Terrestrial Radiation

[2] Outdoor Dose Rates From Radon and its Decay Products

[3] Dose Rates from Ingested Radio-nuclides [Primordial and Cosmogenic]

[4] Dose Rates from Building Materials

12

## COMMENTARY

OMISSIONS

[5] Dose Rates from Airline Travel

[6] Influence of Type of Housing

[7] Influence of Snow on the Roofs of Homes and on the Ground in Terms of External Cosmic and Terrestrial Dose Rates

[8] Influence of Snow on the Ground in Terms of Radon Dose Rates

13

## COMMENTARY

Although it is not Clear, it Appears That the USEPA Dose Rate Estimates Were Based on a 100% Indoor Occupancy Factor

If so, This Would Yield Estimates That are High by Perhaps 10% to 20%

14

## RADON DOSE CONVERSION FACTOR*

IMPORTANT OBSERVATION

Dose Rates for Radon and Its Decay Products in the Mauro and Briggs Report Were Based on a Ratio of 9.6 mSv per Working Level Month [WLM]; NCRP Scientific Committee 85 Now Recommends a Ratio of 4.8 mSv per WLM

15

## RADON DOSE CONVERSION FACTOR*

A Relationship Based on the NCRP Recommendation Was Expressed by UNSCEAR in the Year 2000 as Follows:

$$9 \text{ nSv } (\text{Bq h m}^{-3})^{-1}$$

To Resolve Minor Differences in the Two Conversion Factors, the UNSCEAR Value, Applied in the Assessments That Follow, Was Increased to 9.6 nSv $(\text{Bq h m}^{-3})^{-1}$

16

## RADON DOSE CONVERSION FACTOR

REFERENCE

UNSCEAR, "Report of the United Nations Scientific Committee on the Effects of Atomic Radiation to the General Assembly," Appendix B, §153, page 107 [2000]

17

## ORIGINAL USEPA PLAN

The Original USEPA Plan was to set a Standard That "would represent a level of incremental exposure such that the total annual exposure of the RMEI could be comparable to the total natural radiation exposures incurred now by current residents of well-populated areas." [USEPA Proposed Rule, 2005, Middle Column, page 49036]

18

## CHANGE IN PLANS

The USEPA Stated That Dose Rates for the Amargosa Valley Were not Estimated Since the "Data Were Not Available" [USEPA Proposed Rule, 2005, Footnote, page 49037]

Therefore, Estimates of the Differences in Dose Rates Were Based on the Average for the State of Colorado Compared to That for the Amargosa Valley, the Latter Being Based on an Adjusted Value for the State of Nevada

19

## INDEPENDENT ASSESSMENT

GENERAL APPROACH FOR REVIEW

[1] Apply a Scientific Approach

[2] Indicate the Assumptions Made

[3] Cite Detailed References for the Sources of Data

[4] When Options are Available, Seek to Apply the Data Based on Direct Measurements, and to Cross Check to Ensure Compatibility With Other Data

20

## INDEPENDENT ASSESSMENT

GENERAL APPROACH FOR REVIEW

[5] Exercise Care Not to Overestimate the Dose Rates for the Higher Natural Background Areas

[6] Exercise Care Not to Underestimate the Dose Rates for the Lower Background Area [i.e., the Amargosa Valley]

21

## INDEPENDENT ASSESSMENT

FINDINGS

A Search of the Literature Showed That Data for the Amargosa Valley Were Available. The Same Proved True for Leadville, a Comparable Community in Colorado

Therefore, for Purposes of the First Set of Analyses, the Effective Dose Rates due to Exposures from Natural Background Radiation to Residents in These Two Communities Will Served as a Basis for Comparison

22

## EPA PROPOSED YUCCA MOUNTAIN STANDARDS

REFERENCE

Maheras, Steven, "Environmental Baseline File for Human Health" [Yucca Mountain Site], Report EIS: AR-GEN-35716, TRW Environmental Safety Systems [1999].

23

## ADVANTAGES OF THIS COMPARISON*

Leadville met the Requirements of the ICRP and the USEPA – It has a Relatively High Cosmic Radiation Dose Rate – Being at an Altitude of 3,200 Meters [10,500 Feet], and a High Terrestrial Dose Rate

It Also had Relatively High, but Not Excessive, Indoor Radon Concentrations

24

## ADVANTAGES OF THE COMPARISON

The two Communities are Located in Similar Regions of the U.S.

The Leadville Population [~2,600] is Comparable to That of the Amargosa Valley [~1,150]

Site-Specific Data are Available

Uncertainties are Reduced

25

## ANALYTICAL REFINEMENTS

Both Indoor and Outdoor Dose Rates Were Estimated for Cosmic, Terrestrial, and Radon Exposures

These Included the Application of Occupancy Factors – 0.2 for Outdoors; 0.8 for Indoors [UNSCEAR, 2000; NCRP, 1987]

Dose Rates for Ingested Radionuclides, and Impacts of Building Construction Factors Were Also Included

26

## ANALYTICAL REFINEMENTS

Shielding Factors Were Applied to Account for Attenuation in Buildings – *Note*: These Factors Had Also Been Applied in the Report Developed by Mauro and Briggs

Roof Structures Were Assumed to Attenuate Cosmic Radiation by 20%; Floor and Support Structures Were Assumed to Attenuate Terrestrial Radiation by 20% [UNSCEAR, 2000]

27

## ANALYTICAL REFINEMENTS

Effective Dose Rates From Ingested Naturally Occurring Radionuclides, and External Exposures from Naturally Occurring Radionuclides in Building Materials Were Also Included

Site Specific Refinements Were Also Incorporated Into the Assessments for Leadville and the Amargosa Valley

28

## LEADVILLE ASSESSMENTS*

SNOW COVER

UNSCEAR, 2000, Estimates That Snow Cover on the Ground Reduces the Terrestrial Dose Rate by About 1% per Centimeter Depth [Appendix B, §51, page 91]

Snow Cover Also Retards the Release of Radon into the Outdoor Air

29

## AMARGOSA VALLEY ASSESSMENTS

IMPACT OF MOBILE HOMES

About 91% of the Amargosa Valley Residents Live in Mobile Homes [Rautenstrauch, et al., 2003, pages 2-6]

Factors That Need to be Considered Include the Implications Relative to Structural Shielding Factors for Cosmic and Terrestrial Radiation, and for Radon Concentrations Indoors

30

## AMARGOSA VALLEY ASSESSMENTS

REFERENCE

Rautenstrauch, K. R., Smith, Anthony J., and Andrews, Robert, "Technical Basis Document No. 12: Biosphere Transport,' Revision 1, U.S. Department of Energy, OCRWM, North Las Vegas, NV [2003]

*Comment*: According to the North Carolina Manufactured Housing Institute, 8% of the NC Population Reside in Mobile Homes

31

## MOBILE HOME ASSESSMENTS

STRUCTURAL SHIELDING

Mobile Homes Must Meet the Requirements of the "Code of National Manufactured Home Construction and Safety Standards," Which was Promulgated by the U.S. Department of Housing and Urban Development in 1974

As Such, They Provide the Same Shielding Reduction Factors for Cosmic & Terrestrial Radiation as Conventional Homes

32

## MOBILE HOME ASSESSMENTS

INDOOR RADON

Mobile Homes are Typically Placed on Supports Such That the Floor is a Foot or More Above the Ground. For This Reason, There is a Relatively Small [if any] Pressure Gradient to "Force" the Radon, Released From the Ground, to Move Into the Home

As Such, the Indoor Concentration Will, at Most, be Equal to That Outdoors

33

## MOBILE HOME ASSESSMENTS

INDOOR RADON

Discussions With the Radon Control Program Directors in Florida and North Carolina, and in the USEPA, Confirmed This Conclusion

In Addition, Because the Indoor Radon Decay Product Equilibrium Factor is 0.4, Compared to 0.6 Outdoors, This Reduces the Accompanying Indoor Effective Dose Rate to 67% of That Outdoors per Unit Radon Concentration

34

## MOBILE HOME ASSESSMENTS

INDOOR RADON

Another Factor of Interest is That a "Majority" of the Mobile Homes Sold Today are Equipped With Ceiling Fans.

Such Fans Reduce the Indoor Concentration of Radon Decay Products by 50%, Thus Reducing the Indoor Dose Rate by an Additional Factor of 2

35

## AMARGOSA VALLEY ASSESSMENTS

REFERENCE

Hinds, W. C., Rudnick, S. N., Maher, E. F., and First, M. W., "Control of Indoor Radon Decay Products by Air Treatment Devices," Journal of the Air Pollution Control Association, Vol. 33, No. 2, pages 134 -136 [1983]

36

## MOBILE HOME ASSESSMENTS

INDOOR RADON

Some May Assume That the Amargosa Valley Population Will in Time Live in Conventional Homes Built on the Ground, With Many Having Basements

Such Postulation is Not Permitted; the Regulations Define the RMEI "as Having a Lifestyle and Diet Representative of Current Residents of the Amargosa Valley" [USEPA, 2005, page 49037, left column]

37

## DOSE RATES AMARGOSA VALLEY

In The Slides That Follow, Dose Rate Estimates will be Presented for Indoor and Outdoor Sources of:

- Cosmic and Terrestrial Radiation
- Inhaled Radon Decay Products
- Ingested Food and Water
- Miscellaneous Sources

38

## COSMIC DOSE RATE

AMARGOSA VALLEY: OUTDOORS

Effective Dose Rate: 0.39 mSv $y^{-1}$

Applying an Occupancy Factor of 20%, This Yields a Prorated Dose Rate of:

[0.39 mSv $y^{-1}$] x [0.2] = 0.08 mSv $y^{-1}$

39

## COSMIC DOSE RATE

AMARGOSA VALLEY: INDOORS

Adjusting for Structural Shielding, this yields a Dose Rate of:

[0.39 mSv $y^{-1}$] x [0.8] = 0.31 mSv $y^{-1}$

Applying an Occupancy Factor of 80%, This Yields a Prorated Dose Rate of:

[0.31 mSv $y^{-1}$] x [0.8] = 0.25 mSv $y^{-1}$

40

## COSMIC DOSE RATE

AMARGOSA VALLEY: TOTAL

The Total Amargosa Valley Cosmic Dose Rate is Therefore Equal to:

[0.08 mSv $y^{-1}$] + [0.25 mSv $y^{-1}$] = 0.33 mSv $y^{-1}$

41

## TERRESTRIAL DOSE RATE

AMARGOSA VALLEY: OUTDOORS

Effective Dose Rate: 0.56 mSv $y^{-1}$

Applying an Occupancy Factor of 20%, This Yields a Prorated Dose Rate of:

[0.56 mSv $y^{-1}$] x [0.2] = 0.11 mSv $y^{-1}$

42

## TERRESTRIAL DOSE RATE

AMARGOSA VALLEY: INDOORS

Outdoor Dose Rate: 0.56 mSv $y^{-1}$

Applying a Structural Shielding Reduction Factor of 20%, This Yields an Indoor Dose Rate of:

[0.56 mSv $y^{-1}$] x [0.8] =0.45 mSv $y^{-1}$

Applying an Occupancy Factor of 0.8, This Yields a Prorated Indoor Dose Rate of:

[0.45 mSv $y^{-1}$] x [0.8] = 0.36 mSv $y^{-1}$

43

## TERRESTRIAL DOSE RATE

AMARGOSA VALLEY: TOTAL

The Total Amargosa Valley Terrestrial Dose Rate is Therefore Equal to:

[0.11 mSv $y^{-1}$] + [0.36 mSv $y^{-1}$]
= 0.47 mSv $y^{-1}$

44

## RADON DOSE RATE*

AMARGOSA VALLEY: OUTDOORS

Outdoor Concentration: 0.34 pCi $L^{-1}$ [12.6 Bq $m^{-3}$]; Prorated for an Occupancy Factor of 0.2, This Equals an Exposure Time of 1,760 h $y^{-1}$

Applying the Modified UNSCEAR Equation, and an Equilibrium Factor of 0.6, This Yields a Dose Rate of:

[12.6 Bq $m^{-3}$] x [0.6] x [1760 h $y^{-1}$] x [9.6 nSv (Bq h $m^{-3})^{-1}$]
= 0.13 x $10^6$ nSv $y^{-1}$ = 0.13 mSv $y^{-1}$

45

## RADON DOSE RATE

AMARGOSA VALLEY: INDOORS

As Noted Earlier, the Radon Concentration in the *Mobile* Homes is Assumed to be the Same as Outdoors: 0.34 pCi $L^{-1}$ [12.6 Bq $m^{-3}$].

Prorated for an Occupancy Factor of 0.8 [7,000 h $y^{-1}$], Assuming That 91% of the Population Live in Such Homes, and Applying an Equilibrium Factor of 0.4, This Yields an Indoor Dose Rate of:

[12.6 Bq $m^{-3}$] x [0.4] x [0.91] x [7000 h $y^{-1}$]
x [9.6 nSv (Bq h $m^{-3})^{-1}$]
= 0.31 x $10^6$ nSv $y^{-1}$ = 0.31 mSv $y^{-1}$

46

## RADON DOSE RATE

AMARGOSA VALLEY: INDOORS

The Radon Concentration in *Conventional* Homes Will be Based on the LBNL Database, Namely: 1.25 pCi $L^{-1}$ [46.2 Bq $m^{-3}$].

Prorated for an Occupancy Factor of 0.8 [7,000 h $y^{-1}$], Assuming That 9% of the Population Live in Such Homes, and Applying an Equilibrium Factor of 0.4, This Yields a Dose Rate of:

[46.2 Bq $m^{-3}$] x [0.4] x [0.09]
x [7000 h $y^{-1}$] x [9.6 nSv (Bq h $m^{-3})^{-1}$]
= 0.11 x $10^6$ nSv $y^{-1}$ = 0.11 mSv $y^{-1}$

47

## RADON DOSE RATE

AMARGOSA VALLEY: TOTAL

On This Basis, the Total *Indoor* Dose Rate for Residents of the Amargosa Valley is:

[0.31 mSv $y^{-1}$] + [0.11 mSv $y^{-1}$]
= 0.42 mSv $y^{-1}$

Combined With the *Outdoor* Dose Rate, This Yields a Total of:

[0.42 mSv $y^{-1}$] + [0.13 mSv $y^{-1}$]
= 0.55 mSv $y^{-1}$

48

## OTHER SOURCES OF EXPOSURE

Dade Moeller & Associates

### INGESTED RADIONUCLIDES

The NCRP [Report No. 94, 1987] Estimates an Annual Dose Rate Due to Internally Deposited Radionuclides [Exclusive of Radon Decay Products] of:

0.40 mSv $y^{-1}$

The Primary Contributor is $^{40}K$ [0.15 to 0.19 mSv $y^{-1}$]; Others Include $^{226}Ra$, $^{210}Pb$ - $^{210}Po$, and $^{228}Ra$ - $^{228}Th$, With Much Lesser Dose Rates

Cosmogenic Radionuclides Contribute an Additional

0.01 mSv $y^{-1}$

49

## INGESTED RADIONUCLIDES

Dade Moeller & Associates

### REFERENCE


NCRP, "Exposure of the Population in the United States and Canada from Natural Background Radiation," Report No. 94, National Council on Radiation Protection and Measurements, Bethesda, MD [1987]


50

## INGESTED RADIONUCLIDES

Dade Moeller & Associates

### INGESTED RADIONUCLIDES

The Concentrations of $^{226}Ra$ + $^{228}Ra$ Were Relatively High in the Ground Water in the Amargosa Valley. The Estimated Dose Rate, However, was Only:

6.54 μSv $y^{-1}$

Because Surface Waters Serves as the Primary Source of Drinking Water in Leadville, CO, These Assessments Were not Pursued Further

51

## DOSE RATES AMARGOSA VALLEY

Dade Moeller & Associates

| Source | Dose Rate [mSv $y^{-1}$] |
|---|---|
| Cosmic [Outdoors] | 0.08 |
| [Indoors] | 0.25 |
| Terrestrial [Outdoors] | 0.11 |
| [Indoors] | 0.36 |
| Radon [Outdoors] | 0.13 |
| [Indoors] | 0.42 |
| Ingested Nuclides | 0.41 |
| Total | 1.76 |

52

## LEADVILLE, CO

Dade Moeller & Associates

### COSMIC DOSE RATE: OUTDOORS

Effective Dose Rate: 1.25 mSv $y^{-1}$

Once Again, Applying an Occupancy Factor of 0.2, This Yields a Prorated Outdoor Effective Dose Rate of:

[1.25 mSv $y^{-1}$] x [0.2] = 0.25 mSv $y^{-1}$

53

## LEADVILLE: COSMIC DOSE RATE

Dade Moeller & Associates

### REFERENCES


NCRP, 1987, Report No. 94, page 23

Bouville, A., and Lowder, W. M., "Human Population Exposure to Cosmic Radiation," Radiation Protection Dosimetry, Vol. 24, No. 1/4, pages 293-299 [1988]


54

## LEADVILLE: COSMIC DOSE RATE

INDOORS [SUMMER]

Accounting for Structural Shielding, and an Occupancy Factor of 0.4, the Pro-rated *Indoor Summer* Cosmic Radiation Dose Rate Would be:

[1.25 mSv $y^{-1}$] x [0.8] x [0.4]
= 0.40 mSv $y^{-1}$

55

## LEADVILLE: COSMIC DOSE RATE

INDOORS [WINTER]

In This Case, the Outdoor Dose Rate [1.25 mSv $y^{-1}$] Must be Adjusted Not Only to Account for Structural Shielding, and Occupancy, But Also for the Shielding Due to Snow Cover on the Roofs of the Homes in the Winter [Assumed to Last for 6 Months]

56

## LEADVILLE: COSMIC DOSE RATE

SNOW COVER ADJUSTMENTS

UNSCEAR [2000, Appendix B, §51, page 91] Estimates That Snow Cover on the Ground Reduces the *Terrestrial* Dose Rate by About 1% per Centimeter Depth

Assuming An Average of 50 cm Roof Snow Cover, & That the *Cosmic* Dose Rate Would be Equally Reduced, This Would Require the Incorporation of a Multiplication Factor of 0.5 for Computing *Indoor Winter* Cosmic Dose Rates

*Note*: This is a "Conservative" Assessment

57

## LEADVILLE: COSMIC DOSE RATE

INDOORS [WINTER]

Accounting for the Previously Identified Factors, and Assigning a 6 Month Occupancy Factor of 0.4, the *Indoor Winter* Cosmic Radiation Dose Rate Would be:

[1.25 mSv $y^{-1}$] x [0.8] x [0.5] x [0.4]
= 0.20 mSv $y^{-1}$

58

## LEADVILLE: COSMIC DOSE RATE

INDOORS [TOTAL]

On This Basis, the Total Indoor Cosmic Radiation Dose Rate to the Residents of Leadville, CO, Would be:

= [0.40 mSv $y^{-1}$] + [0.20 mSv $y^{-1}$]
= 0.60 mSv $y^{-1}$

59

## LEADVILLE: TOTAL COSMIC DOSE RATE

On This Basis, the Total Estimated Total Cosmic Radiation Dose Rate to the Residents of Leadville, CO, is:

[0.60 mSv $y^{-1}$] + [0.25 mSv $y^{-1}$]
= 0.85 mSv $y^{-1}$

60

## TERRESTRIAL DOSE RATE

LEADVILLE, CO: OUTDOORS

Based on Estimates Quoted In Various Reports, the Estimated Outdoor Terrestrial Dose Rate is:

1.20 mSv $y^{-1}$

This Compares to an Estimated Average Terrestrial Dose Rate for the State of Colorado of 1.17 mSv $y^{-1}$ [Oakley, 1972] and to An Average Rate of 0.90 mSv $y^{-1}$ for the Colorado Plateau, Which Covers ~35% of the Southwest Portion of the State [NRC, 1990]

61

## TERRESTRIAL DOSE RATE

REFERENCES


Oakley, Donald T., "Natural Radiation Exposure in the United States," Report ORP/SID 72-1, Office of Radiation Programs, U.S. Environmental Protection Agency, Washington, DC [1972]

National Research Council, "The Effects on Populations of Exposure to Low Levels of Ionizing Radiation: 1980" [The BEIR III Report], National Academy Press, Washington, DC [1990]


62

## TERRESTRIAL DOSE RATE

LEADVILLE, CO: OUTDOORS [WINTER]

The Typical Winter Ground Snow Cover is 3 to 4 Feet [90 – 120 cm]

The Snow, However, is Generally Removed From Sidewalks and Pathways

Therefore, it Will be Assumed That Public Exposures to Terrestrial Radiation Sources Will be the Same as in Summer

63

## TERRESTRIAL DOSE RATE

LEADVILLE, CO: OUTDOORS

On This Basis, the Overall Outdoor Dose Rate Would be:

1.20 mSv $y^{-1}$

Applying an Occupancy Factor of 20%, This Yields a Dose Rate of:

$[1.20 \text{ mSv y}^{-1}] \times [0.2]$

$= 0.24 \text{ mSv y}^{-1}$

64

## TERRESTRIAL DOSE RATE

LEADVILLE, CO: INDOORS

The Snow Cover Will not Affect the Indoor Dose Rate From Terrestrial Radiation.

Applying a Structural Shielding Factor of 0.8 and an Occupancy Factor of 0.8, the Estimated *Indoor* Dose Rate from This Source is:

$[1.20 \text{ mSv y}^{-1}] \times [0.8] \times [0.8]$

$= [0.77 \text{ mSv y}^{-1}]$

65

## OTHER INDOOR SOURCES

CONSTRUCTION MATERIALS

Building Materials, Such as Concrete and Brick, Can be Sources of External Radiation Exposure in Homes

According to NCRP Report No. 95 [1987], the Accompanying Dose Rate for Residents in Such Homes is About:

0.07 mSv $y^{-1}$

66

## OTHER INDOOR SOURCES

CONSTRUCTION MATERIALS

Assuming That 40% to 50% of the Leadville Residents Receive Exposures From These Sources, and Applying an Occupancy factor of 0.8, This Would Add About 0.02 mSv $y^{-1}$ To Their Indoor Dose Rates

67

## OTHER INDOOR SOURCES

REFERENCE


NCRP, "Radiation Exposure of the U.S. Population From Consumer Products and Miscellaneous Sources," National Council on Radiation Protection and Measurements, Bethesda, MD, Report No. 95 [1987]


68

## TOTAL TERRESTRIAL DOSE RATE

LEADVILLE, CO

On This Basis, the Total Dose Rate From Terrestrial Sources [*Outdoors* + *Indoors*], Combined With the Contribution From External Exposures to Building Materials, Would be:

$$[0.24 \text{ mSv y}^{-1}] + [0.77 \text{ mSv y}^{-1}] + [0.02 \text{ mSv y}^{-1}] = 1.03 \text{ mSv y}^{-1}$$

69

## RADON DOSE RATE

LEADVILLE, CO: OUTDOORS [SUMMER]

Based on Studies by Borak and Baynes [1999], and Stone et al. [1999], the *Outdoor* Radon Concentration in Leadville was Estimated to be 31.3 Bq $m^{-3}$

Adjusted for the Factors Previously Cited, and Applying an Occupancy Factor of 0.1 [880 h $y^{-1}$], This Yields an Estimated *Summer* Dose Rate of:

$$[31.3 \text{ Bq m}^{-3}] \times [0.6] \times [880 \text{ h y}^{-1}] \times [9.6 \text{ nSv (Bq h m}^{-3})^{-1}] = 0.16 \times 10^6 \text{ nSv y}^{-1} = 0.16 \text{ mSv y}^{-1}.$$

70

## RADON DOSE RATE

REFERENCES


Borak, T. B., and Baines, S. A., "Continuous Measurements of Outdoor $^{222}Rn$ Concentrations for Three Years at One Location in Colorado," Health Physics, Vol. 76, No. 4, pages 418-420 [April, 1999].

Stone, M. J., Whicker, R. D., Ibrahim, S. A., and Whicker, F. W., "Spatial Variations in Natural Background Radiation: Absorbed Dose Rates in Air in Colorado," Health Physics, Vol. 76, No. 5, pages 516-523 [May, 1999].


71

## RADON DOSE RATE

LEADVILLE, CO: OUTDOORS [WINTER]

Winter Snow Cover Essentially Seals the Radon in the Soil. For This Reason, it was Assumed That the Outdoor Winter Radon Concentrations in Leadville Were Equal to the Average Outdoor Value for the Northern Hemisphere, Namely, 8 Bq $m^{-3}$.

Adjusted for the Factors Previously Cited, and Applying an Occupancy Factor of 0.1 [880 h $y^{-1}$], This Yields an Estimated Dose Rate of:

$$[8 \text{ Bq m}^{-3}] \times [0.6] \times [880 \text{ h y}^{-1}] \times [9.6 \text{ nSv (Bq h m}^{-3})^{-1}] = 0.04 \times 10^6 \text{ nSv y}^{-1} = 0.04 \text{ mSv y}^{-1}$$

72

## RADON DOSE RATE

LEADVILLE, CO: OUTDOORS [TOTAL]

On This Basis, the Total Effective Dose Rate Due to the Inhalation of Outdoor Radon by Residents of Leadville, CO, is Estimated to be:

$[0.16 \text{ mSv y}^{-1}] + [0.04 \text{ mSv y}^{-1}]$

$= 0.20 \text{ mSv y}^{-1}$

73

## RADON DOSE RATE

LEADVILLE, CO: INDOORS

The Average Radon Concentration in the Homes, Based on the LBNL Database is:

$3.49 \text{ pCi L}^{-1} [129 \text{ Bq m}^{-3}]$.

Prorated for an Occupancy Factor of 0.8 [7,000 h $y^{-1}$], And Applying a Radon Decay Product Equilibrium Factor of 0.4, This Yields an Indoor Dose Rate of:

$[129 \text{ Bq m}^{-3}] \times [0.4] \times [7000 \text{ h y}^{-1}] \times [9.6 \text{ nSv (Bq h m}^{-3})^{-1}]$

$= 3.47 \times 10^6 \text{ nSv y}^{-1} = 3.47 \text{ mSv y}^{-1}$

74

## RADON DOSE RATE

REFERENCE

Lawrence Berkeley National Laboratory (LBNL), "High-Radon Program," Berkeley, CA.

This Includes a Continuously Updated County-by-County Database on Radon Concentrations in the United States

Accessible at:

http://eetd.lbl.gov/IEP/high-radon/files.html

75

## SUMMARY: EFFECTIVE DOSE RATES

| Source | Leadville, Colorado | Amargosa Valley |
|---|---|---|
| Cosmic [Outdoors] | 0.25* | 0.08* |
| [Indoors] | 0.60 | 0.25 |
| Terrestrial [Outdoors] | 0.24 | 0.11 |
| [Indoors] | 0.79 | 0.36 |
| Radon [Outdoors] | 0.20 | 0.13 |
| [Indoors] | 3.47 | 0.42 |
| Ingested Nuclides | 0.41 | 0.41 |
| Total | 5.96 | 1.76 |

*All dose rates are expressed in units of mSv $y^{-1}$

76

## DOSE RATE DIFFERENCE

LEADVILLE VS. AMARGOSA VALLEY

On This Basis, the Total Effective Dose Rate Due to Exposure to Natural Background Radiation Sources by Residents in Leadville, CO, is Estimated to be Higher Than That for Those in the Amargosa Valley by:

$[5.96 \text{ mSv y}^{-1}] - [1.76 \text{ mSv y}^{-1}]$

$= 4.20 \text{ mSv y}^{-1}$

77

## CONSERVATISMS*

These Include:

[a] Applying the Revised Radon Dose Coefficient

[b] Accounting for Snow Cover in Terms of Reductions in Indoor Cosmic, and Outdoor Radon Dose Rates, and Assuming That the Duration of Winter is 6 Months

[c] Accounting for the Removal of Snow From Walkways in Estimating Outdoor Terrestrial Dose Rates

78

## CONSERVATISMS*

CONTINUED

[d] Not Accounting for Snow Cover as a Source of an Increase in the Pressure Gradient Relative to Indoor Radon Dose Rates

[e] Assuming Ground Snow Cover Reduces the Cosmic Dose Rate by the Same Amount as the Terrestrial Rate

[f] Not Accounting for Ceiling Fans in Estimating Indoor Radon Dose Rates in Mobile Homes

79

## DOSE RATES: STATE OF COLORADO

Once Again, the Dose Rates Will be Estimated for Outdoor and Indoor Sources of:

- Cosmic and Terrestrial Radiation
- Inhaled Radon Decay Products
- Ingested Food and Water
- Miscellaneous Sources

80

## COSMIC DOSE RATE

STATE OF COLORADO: OUTDOORS

The Cosmic Radiation Dose Adjusted to Include the Building Shielding Factor [Mauro and Briggs, 2005] was 0.475 mSv $y^{-1}$

Adjusting This to Remove the Shielding Factor Yields and Outdoor Dose Rate of:

[0.475 mSv $y^{-1}$] ÷ [0.8] = 0.59 mSv $y^{-1}$

Applying an Occupancy Factor of 0.2, This Yields a Prorated Dose Rate of:

[0.59 mSv y-1] x [0.2] = 0.12 mSv $y^{-1}$

81

## COSMIC DOSE RATE

STATE OF NEVADA: INDOORS

Applying the the Dose Rate, Adjusted for the Building Shielding Factor, the Prorated Indoor Dose Rate Would be:

[0.475 mSv $y^{-1}$] x [0.8] = 0.38 mSv $y^{-1}$

Note: Since Definitive Data Were Not Available, the Impacts of Winter Snow Cover on the Roofs of the Houses was Not Taken into Account.

82

## COSMIC DOSE RATE

STATE OF COLORADO: TOTAL

On This Basis, the Estimated Total Cosmic Dose Rate Would be:

[0.12 mSv $y^{-1}$] + [0.38 mSv $y^{-1}$]
= 0.50 mSv $y^{-1}$

83

## TERRESTRIAL DOSE RATE

STATE OF COLORADO: OUTDOORS

According to Mauro & Briggs [2005], the Terrestrial Dose Rate for the State of Colorado, Including a Building Shielding Factor of 0.8, is 0.426 mSv $y^{-1}$

Adjusting this Estimate, the Outdoor Dose Rate Would be:

[0.426 mSv $y^{-1}$] ÷ [0.8] = 0.53 mSv $y^{-1}$

84

## TERRESTRIAL DOSE RATE

Dade Moeller & Associates

STATE OF COLORADO: OUTDOORS

Applying an Occupancy Factor of 0.2, This Yields a Prorated Outdoor Dose Rate of:

[0.53 mSv $y^{-1}$] x [0.2] = 0.11 mSv $y^{-1}$

85

## TERRESTRIAL DOSE RATE

Dade Moeller & Associates

STATE OF COLORADO: INDOORS

Applying an Occupancy Factor of 0.8 to the Mauro & Briggs Indoor Dose Rate of 0.426 mSy $y^{-1}$, the Prorated Indoor Dose Rate Would be:

[0.426 mSv $y^{-1}$] x [0.8] = 0.34 mSv $y^{-1}$

86

## TERRESTRIAL DOSE RATE

Dade Moeller & Associates

STATE OF COLORADO: INDOORS

Adding a Contribution of 0.03 mSv $y^{-1}$ due to Naturally Occurring Radionuclides in Building Materials Yields a Total Estimated Indoor Dose Rate of:

[0.34 mSv $y^{-1}$] + [0.03 mSv $y^{-1}$]

= 0.37 mSv $y^{-1}$

87

## TERRESTRIAL DOSE RATE

Dade Moeller & Associates

STATE OF COLORADO: TOTAL

On This Basis, the Total Estimated Dose Rate From Terrestrial Radiation, and Building Materials, is:

[0.11 mSv $y^{-1}$] + [0.37 mSv $y^{-1}$]

= 0.48 mSv $y^{-1}$

88

## RADON DOSE RATE

Dade Moeller & Associates

STATE OF COLORADO: OUTDOORS

Since the Data Were Not Available, It Will be Assumed That the Average Outdoor Radon Concentration is the Same as That in Fort Collins [18 Bq $m^{-3}$]. Applying an Equilibrium Factor of 0.6, This Yields an Estimated Prorated Outdoor Dose Rate of:

[18 Bq $m^{-3}$] x [0.6] x [1760 h $y^{-1}$] x [9.6 nSv (Bq h $m^{-3})^{-1}$]
= 0.18 x $10^6$ nSv $y^{-1}$ = 0.18 mSv $y^{-1}$

89

## RADON DOSE RATE

Dade Moeller & Associates

STATE OF COLORADO: INDOORS

Based on the LBNL "High-Radon" Database, the Average Indoor Radon Concentration in Colorado is 2.89 pCi $L^{-1}$ [107 Bq $m^{-3}$].

Applying the Modified UNSCEAR Equation, and an Equilibrium Factor of 0.4, This Yields a Dose Rate of:

[107 Bq $m^{-3}$] x [0.4] x [7000 h $y^{-1}$] x [9.6 nSv (Bq h $m^{-3})^{-1}$]
= 2.88 x $10^6$ nSv $y^{-1}$ = 2.88 mSv $y^{-1}$.

90

## RADON DOSE RATE

STATE OF COLORADO: TOTAL

On This Basis, the Total Radon Dose Rate for Residents of the State of Colorado Would be:

$[0.18\ mSv\ y^{-1}] + [2.88\ mSv\ y^{-1}]$
$= 3.06\ mSv\ y^{-1}$

91

## SUMMARY: EFFECTIVE DOSE RATES

| Source | State of Colorado | Amargosa Valley |
|---|---|---|
| Cosmic [Outdoors] | 0.12* | 0.08* |
| [Indoors] | 0.38 | 0.25 |
| Terrestrial [Outdoors] | 0.11 | 0.11 |
| [Indoors] | 0.37 | 0.36 |
| Radon [Outdoors] | 0.18 | 0.13 |
| [Indoors] | 2.88 | 0.42 |
| Ingested Nuclides | 0.41 | 0.41 |
| Total | 4.45 | 1.76 |

*All dose rates are expressed in units of $mSv\ y^{-1}$

92

## DOSE RATE DIFFERENCE

COLORADO VS. AMARGOSA VALLEY

On This Basis, the Total Effective Dose Rate From the Major Natural Background Radiation Sources to Residents in the State of Colorado is Estimated to be Higher Than That for Those in the Amargosa Valley by:

$[4.45\ mSv\ y^{-1}] - [1.76\ mSv\ y^{-1}]$
$= 2.69\ mSv\ y^{-1}$

93

## DOSE RATES: STATE OF NEVADA

Once Again, the Dose Rates Were Estimated for Outdoor and Indoor Sources of:

- Cosmic and Terrestrial Radiation
- Inhaled Radon Decay Products
- Ingested Food and Water
- Miscellaneous Sources

94

## DOSE RATES: STATE OF NEVADA

On the Basis of These Estimates, Which Followed the Methodologies Previously Outlined, the Dose Rates for Each of the Primary Sources for the State of Nevada Were as Summarized in the Table That Follows.

95

## SUMMARY: EFFECTIVE DOSE RATES

| Source | State of Nevada | Amargosa Valley |
|---|---|---|
| Cosmic [Outdoors] | 0.09* | 0.08* |
| [Indoors] | 0.30 | 0.25 |
| Terrestrial [Outdoors] | 0.05 | 0.11 |
| [Indoors] | 0.20 | 0.36 |
| Radon [Outdoors] | 0.13 | 0.13 |
| [Indoors] | 1.64 | 0.42 |
| Ingested Nuclides | 0.41 | 0.41 |
| Total | 2.82 | 1.76 |

*All dose rates are expressed in units of $mSv\ y^{-1}$

96

## DOSE RATE DIFFERENCE

NEVADA VS. AMARGOSA VALLEY

On This Basis, the Total Effective Dose Rate From the Major Natural Background Radiation Sources to Residents in the State of Nevada is Estimated to be Higher Than That for Those in the Amargosa Valley by:

$$[2.82\ mSv\ y^{-1}] - [1.76\ mSv\ y^{-1}] = 1.06\ mSv\ y^{-1}$$

97

## COMMENTARY

A Major Contributor to This Difference is the Impact on the Indoor Radon Concentrations for the Large Percentage of the Amargosa Valley Residents Who Live in Mobile Homes

If This Difference is Removed, the Estimated Total Dose Rates Will be Essentially the Same; In Fact That is What One Would Have Anticipated

98

## ANOTHER COMPARISON

| Source | | State of Colorado | State of Nevada |
|---|---|---|---|
| Cosmic | [Outdoors] | 0.12* | 0.09* |
| | [Indoors] | 0.38 | 0.30 |
| Terrestrial | [Outdoors] | 0.11 | 0.05 |
| | [Indoors] | 0.37 | 0.20 |
| Radon | [Outdoors] | 0.18 | 0.13 |
| | [Indoors] | 2.88 | 1.64 |
| Ingested Nuclides | | 0.41 | 0.41 |
| Total | | 4.45 | 2.82 |

*All dose rates are expressed in units of $mSv\ y^{-1}$

99

## ANOTHER COMPARISON*

As Noted, the Difference in the Dose Rates for the States of Colorado and Nevada is as Follows:

$$[4.45\ mSv\ y^{-1}] - [2.82\ mSv\ y^{-1}] = 1.63\ mSv\ y^{-1}$$

Adjusting for the Reduction in the Radon Dose Conversion Factor, the Difference Would be:

$$[2] \times [1.63\ mSv\ y^{-1}] = 3.26\ mSv\ y^{-1}$$

100

## SUMMARY OF COMPARISONS

| Comparison to Amargosa Valley | Dose Rate Difference* |
|---|---|
| Leadville, CO | 4.20 |
| State of Colorado | 2.69 |
| State of Nevada | 1.06 |

*All dose rates are expressed in units of $mSv\ y^{-1}$

101

## AVAILABLE OPTIONS

The First Option Would be to Base the Standard on a Comparison of the Dose Rate to Residents in Leadville, CO, to Those in the Amargosa Valley

102

## AVAILABLE OPTIONS

The Second Option Would be to Base the Standard on a Comparison of the Dose Rate to Residents in the State of Colorado to Those in the Amargosa Valley

103

## AVAILABLE OPTIONS

The Third, And Very Questionable Option, Would be to Base the Standard on a Comparison of the Dose Rate in the State of Nevada to That in the Amargosa Valley

104

## CLOSING COMMENTARY

The Primary Goal of This Exercise Was to Provide the USEPA, USDOE, AND USNRC With Comparable Dose Rate Estimates Based on the Best Available Scientific Information

How They Interpret and Apply the Results is Their Decision to Make

105

## CLOSING COMMENTARY*

One of the Primary Questions Will be How to Interpret the Role of Indoor Radon as a Contributor to the Total Background Dose Rate Estimates

While the ICRP Recommends the Exclusion of "Large Variations in the Dose Rates From Radon," so Long as the Comparisons are Restricted to Average Dose Rates in Multiple Homes, That Should be Acceptable

106

## EPA PROPOSED YUCCA MOUNTAIN STANDARDS

THE END

107

# SUMMARY FROM EPA HEARINGS

Ruth F. Weiner

1

## Some Statistics

**October 4**

- Open meeting and roundtable: 4PM – 7 PM
  - Very few people before 5 PM
  - About 50 people exclusive of EPA. NRC, other observers
  - Demonstration: "No Nuclear Waste Dump in Nevada"
- Formal hearing 7PM to 9 PM

**October 5**

- Open meeting 10 AM -11AM
  - **About 20 people exclusive of EPA, etc.**
- Formal Hearing 11Am - noon

2

## Major Points Made By EPA

- Reviewed the charge to EPA in the NWPA: to set the standard.
- Reviewed the basic points in 40 CFR Part 197
- Explained the court's decision
- Explained how the new standard was arrived at
  - 350 mrem/year was chosen because much of Colorado has background of about 700 mrem/year
  - Colorado has similar demographics, climate, geography to Nevada
  - 36 states have higher background radiation than the average U. S. background
  - International standards were consulted, although EPA did not identify which particular standards

3

## Major Points Made By Speakers

- The choice of the median for the standard rather than the mean (for 10,000 years to one million years) greatly increases the allowed upper limit to the dose from the repository.
  - This point was reiterated by many speakers
- EPA was quite firm that 15 mrem/year was the largest dose that could protect health for the 10,000 year standard.
  - How can the agency now say that 350 mrem/year is adequately protective?
  - The "step function" aspect of the new standard raises questions.

4

## Points Made By Tribal Speakers

- The land still belongs to Western Shoshone, who don't want "poison into Yucca Mountain"
- Members of the tribe have become ill since nuclear weapons were developed.
- Lack of logic went into writing the new standard.
- Going from 15 mrem/yr to 350 mrem/yr, is going from one death/1000 persons to 1 death /36.
- Other standards are not nearly as lenient as the proposed million-year standard.
- Comment period should be extended for years

5

## Points Made By Speakers from State and Local Governments

- Nevada Attorney General and Governor Guinn's representative
  - EPA developed standards in collusion with DOE
  - EPA has abandoned its responsibility to protect public health.
  - A new rule is needed.
  - Additional points were the same as on the next slides
- Clark County
  - History of the AEC in Nevada shows that people don't trust the government.

6

## Additional Points Made By Organization Speakers

- Sierra Club
  - EPA is cooking the numbers by changing from mean dose to median.
  - Using the median means "A statistical 100% chance of cancer"
  - No concern about radiation effects on non-human species.
  - Leave the waste at the power plants; recycle spent fuel; transportation is harmful to the public.
  - A two tier standard is "not stable."
- Citizen Alert
  - This was not an open process.
  - Your "fix" to the standard is totally unacceptable

7

## Additional Points Made By Other Speakers

- Standards being discussed do not include worker standards.
- Background radiation has little effect on cancer incidence. Why are we using background radiation?
- The standard should be a mixed-waste standard because Yucca Mountain is a mixed waste site.
- Some countries have zero dose at one million years.
- Standard should have been more stringent than 15 mrem.
- Assuming package integrity for 10000 years is preposterous.
- This standard is less stringent than air quality standards.

8

## Points Made By Speakers With A Different Perspective

- UNLV Professor
  - 15 mrem/yr is too small.
  - We spend too much money protecting against fictional risks. 10 rem doesn't seem to cause health effects, so why are we wasting the public's money.
  - 10,000 years is not set for any other pollutant.
  - We need international cooperation.

- Two former test site workers
  - Hiroshima is currently a big city and people live there now. They are not going to build a big city at Mercury.
  - I'm pushing 80 and none of us are dead and we are in pretty good shape.
  - Yucca Mountain is a necessity

9

# PROPOSED REGULATIONS FOR YUCCA MOUNTAIN:

## Implementing A Dose Standard after 10,000 years

Presentation to the
165th meeting of the ACNW
November 14, 2005

Contact:
Dr. Janet P. Kotra
(301) 415-6674

1

# PURPOSE OF NRC'S PROPOSED RULE

- Implement new standards for doses that could occur after 10,000 years
- Specify treatment of climate change at Yucca Mountain after 10,000 years
- Specify that estimates of worker and public doses use the same, current weighting factors

2

## BACKGROUND

- NRC issued final regulations for Yucca Mountain (10 CFR Part 63) in November '01
- They implement final standards (40 CFR 197) issued by the Environmental Protection Agency (EPA) in June '01
- EPA was obligated to develop the standards "based on and consistent with" findings and recommendations of the National Academy of Sciences (NAS)

3

## BACKGROUND (cont.)

- The State of Nevada and others challenged EPA's standards and NRC's regulations in court
- The Court upheld EPA's standards and NRC's regulations on all but one issue: EPA's specification, and NRC's adoption, of a 10,000-year compliance period
- The Court found that EPA's compliance period was not "based on and consistent with" NAS findings as required by law

4

## NEW COMPLIANCE PERIOD

- The Court vacated EPA's compliance period of 10,000 years and NRC's incorporation of that period in its Part 63 regulations
- In response to the Court's ruling, EPA proposed revisions to its standards on August 22, 2005
- NRC must revise its Part 63 regulations to be consistent with revised EPA standards

5

## EPA'S PROPOSED APPROACH

- Continue to apply existing standards for first 10,000 years after disposal
- Add separate requirements for the peak dose, after 10,000 years, within period of geologic stability (one million years)
- Update calculations of all doses based on current dosimetry

6

## PROPOSED REVISIONS

- Limit peak dose after 10,000 years
- Specify criteria that DOE must use in performance assessments that estimate doses after 10,000 years
- Specify weighting factors for DOE's use when calculating individual dose
- State that NRC specify value(s) that DOE use to represent climate change after 10,000 years

7

## DOSE LIMIT

- ***EPA proposal:*** After 10,000 years, and through the period of geologic stability, limit the median value of peak dose estimates to ≤ 3.5 mSv/year (≤ 350 mrem/year)
- ***NRC proposal:*** Incorporate EPA's proposed dose limit into Part 63

8

## CRITERIA FOR PEAK DOSE ASSESSMENT

- ***EPA proposal:***
  - Use assessment of first 10,000 years as basis for projections >10,000 years
  - Specify features, events, and processes that need to be evaluated in assessments of repository performance after 10,000 years (*i.e.,* seismic activity, igneous events, climate variation, and general corrosion)
- ***NRC proposal:*** Incorporate these criteria into Part 63

9

## USE OF CURRENT DOSIMETRY

- ***EPA proposal:*** Require use of weighting factors that reflect current dosimetry and updated models for dose calculations (As provided in Appendix A of 40 CFR 197)
- ***NRC proposal:*** Adopt EPA's specification of current dosimetry in Part 63

10

## WORKER DOSE CALCULATIONS

- ***NRC proposal:*** Consistent with EPA's specification of current weighting factors for calculating doses to the public, revise Part 63 so that the same factors are used for calculating doses to workers

11

## TREATMENT OF CLIMATE VARIATION

- ***EPA proposal:***
  - Assume effects of climate change after 10,000 years result from increased water flow through repository
  - NRC should specify steady-state values for DOE use in projecting long-term impact of climate change

- ***NRC proposal:***
  - Require use of a time-independent deep percolation rate to represent the effect of future climate change
  - Assume a log uniformly distributed range with a mean value approximately six times the current rate

12

## SUMMARY OF PROPOSED REVISIONS TO PART 63

- Adopt EPA limit for peak dose >10,000 yrs
- Adopt EPA criteria for performance assessments used to estimate doses >10,000 years
- Adopt EPA "weighting factors" for calculating individual doses, and require calculation of worker doses using the same factors
- Specify a method for projecting the long-term impact of climate variation >10,000 years

13

## CONCLUSIONS

- NRC believes its existing regulations at 10 CFR Part 63 are protective
- NRC has proposed additional requirements that are consistent with EPA's proposed standards for Yucca Mountain
- NRC will revise its regulations to be consistent with final EPA standards when they are issued

14

CONTENTS

## APPENDICES

**Table 14.** **Potential Candidate Areas to Amend in 10 CFR Part 61.** Taken from Attachment B of NRC (1993).

| 10 CFR Part 61 | | | NRC Staff Recommendation (NRC,1993) |
|---|---|---|---|
| **Requirement** | **Subpart** | **Subject Area** | |
| §61.29 | B | Active Maintenance | In conjunction with a longer time period of institutional control, include provisions in the regulation for more inspections and preventive maintenance of the disposal facility following closure to assure that the facility is performing as intended. |
| §61.41 | C | Performance Objectives | Establish more stringent dose requirements for protection of the general population lower than the current 25 mrem/year. |
| §61.50 | D | Technical Requirements for Land Disposal Facilities | Develop specific technical criteria to cover disposal in above ground vaults (AVGs), which are not currently addressed in the regulations. |
| §61.50(a) | D | Site Suitability Requirements | Current requirements considered to be "minimum" basic requirements. Past experience indicates more specific siting and design requirements are needed. More credit also needed for performance of engineered barriers to compensate for site deficiencies. |
| §61.53 | D | Environmental Monitoring | In conjunction with a longer time period of institutional control, include provisions in the regulation for a period of environmental monitoring after the 100-year caretaker period. |
| §61.59(a) | D | Land Ownership | Consideration should be given to assigning a responsible third party to the caretaker role other than the government. |
| §61.59(b) | D | Institutional Control Period | Extend governmental care taker period for more than 100 years. |
| §§61.55 and 61.56 | D | Waste Classification and Characterization | Specific concentration-averaging requirements are not specified in the regulations |
| n/a | n/a | Retrievability Option | Currently, there is no provision in the regulation to require that the wastes be recoverable should the disposal facility fail to perform as intended. |
| n/a | n/a | Ground-Water Protection Requirements | The regulation could be made more explicit on how the ground-water resource would be protected. ACNW has previously recommended specific regulatory action in this area. |