

NUCLEAR REGULATORY COMMISSION

ORIGINAL

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~~Estimating the Risk of a Nuclear Accident~~

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1 UNITED STATES OF AMERICA
2 NUCLEAR REGULATORY COMMISSION

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4 ADVISORY COMMITTEE ON NUCLEAR WASTE (ACNW)

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6 BRIEFING ON

7 STATUS OF ESTIMATING PERFORMANCE OF IGNEOUS ACTIVITY

8 + + + + +

9 THURSDAY

10 FEBRUARY 7, 2002

11 + + + + +

12 ROCKVILLE, MARYLAND

13 + + + + +

14 The Commission met in at the Nuclear
15 Regulatory Commission, Two White Flint North, Room
16 T2B1, 11545 Rockville Pike, at 1:30 p.m., B. John
17 Garrick, Chairman, presiding.

18
19 COMMISSIONERS PRESENT:

20 B. JOHN GARRICK, Acting Chairman

21 MILTON N. LEVENSON, Member

22

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1 ACNW STAFF PRESENT:

2 HOWARD J. LARSON, Special Assistant, ACRS/ACNW

3 RICHARD K. MAJOR

4 LYNN DEERING

5 ANDREW C. CAMPBELL

6 LATIF HAMDAN

7 SHER BAHADUR, Associate Director, ACRS/ACNW

8 JOHN T. LARKINS, Executive Director, ACRS/ACNW

9 AMARJIT SINGH, ACRS Staff

10 ALSO PRESENT:

11 BILL HINZE, ACNW Consultant

12

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

(1:30 p.m.)

CHAIRMAN GARRICK: Come to order. As we announced this morning, my name is John Garrick, accompanied by Milt Levenson, another member of the committee, and Bill Hinze, a former member of the committee and consultant. We are short a couple of members of the committee -- George Hornberger, the Chairman, for compelling reasons, and Ray Wymer, Vice Chairman, for other reasons -- so we're going to have to do the best we can. This topic we're going to start off with, the member who has the lead on it happens to be Hornberger but, in his absence today, we're going to lean heavily on former member Bill Hinze and his distinguished knowledge about this topic.

So, with that, I think we will go ahead and start. Tim, are you going to start it?

MR. McCARTIN: And end it hopefully.

(Laughter and simultaneous discussion.)

MR. LARSON: If I were introducing this topic, I'd say, "This is the cat, the cat that has had nine lives, or more".

MR. McCARTIN: Thank you, Dr. Garrick.

(Slide)

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1 Today I'll be talking about the status of
2 estimating performance for igneous activity, and
3 you're right in that I'm starting it. I will give the
4 entire presentation, and let me just say the reason
5 for this is, what we are hoping to do today is give a
6 perspective not so much in terms of the detailed
7 geologic igneous processes involved, but more how
8 we're representing it in the performance assessment
9 and what it means in terms of its implications in
10 terms of the dose.

11 We'll be talking about the differences
12 between ourselves and DOE, et cetera, but today what
13 we're hoping to do is talk more about how things are
14 abstracted in the performance assessment and not
15 really the detailed geologic processes, why I'm here
16 rather than someone like Brit Hill from the Center of
17 John Trapp from the staff. And John Trapp is notable
18 by his absence. He is recovering from some recent
19 surgery, which is why he's not here. I'm sure he'd
20 rather be here than recovering from surgery, that's
21 for sure.

22 (Simultaneous discussion.)

23 MR. McCARTIN: In terms of how I'm going
24 to present things, it's not so much in order, but the
25 topics that I'll address, and what I'm hoping to do is

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1 give some small insight on the uncertainties in
2 estimating volcanic disruption of the repository, talk
3 to differences between the NRC and DOE in our
4 approaches for representing this in the performance
5 assessment, talk to a path forward and, at the very
6 end -- and I'll do those three topics in the context
7 of the "big ticket" items for estimating the
8 performance of the repository.

9 At the end, I'd like to talk briefly about
10 the treatment of uncertainty in NRC's TPA code, and
11 I'm going to draw parallels to what we do in igneous
12 and in the waste package area. It's the beginning of
13 an effort to scope out how we're dealing with
14 uncertainty in the entire code, and we hope to
15 certainly pull out are there discrepancies. We want
16 to see, as Marty Virgilio talked about earlier today,
17 we want to see a consistency in the way we're dealing
18 with uncertainties, get a better handle on it -- it
19 might get to some of the treatment of conservatism, et
20 cetera -- but that's at the very end, and it's a small
21 nugget. We probably will be coming back to it maybe
22 later in some subsequent meeting when we have it
23 fleshed out for the entire code.

24 (Slide)

25 First, as just a general overview -- and

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1 this pretty much gets to what I'll be talking about --
2 what are the areas of uncertainty? Certainly, we have
3 estimating the probability, and then after you get, if
4 it will occur, the consequences, and there we have --
5 I'll talk to five particular topic areas -- the
6 interaction of magma in the repository, magma in the
7 waste package, magma in the waste form, the
8 redistribution of volcanic ash after the event has
9 occurred, you have an ash deposit, how may it
10 redistribute in time, and then, ultimately, for the
11 exposure scenario, the inhalation is the dominant
12 pathway. And so I'll be talking to each one of these
13 with respect to those -- the uncertainties, the
14 approaches, and the path forward.

15 CHAIRMAN GARRICK: Are there areas that we
16 should have our attention called to that have gone
17 through some change in the last few months?

18 MR. McCARTIN: I'll try to address that.
19 I think there have been some changes in the DOE
20 program. I certainly will be talking to things that
21 we're in the process of examining and I think in the
22 next six months to a year, we -- I won't guarantee
23 that we have changes, but we'll have hopefully at
24 least increased confidence in the approach we have if
25 it doesn't change. But I will try to talk to that as

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1 I go through.

2 Right now, in terms of resolutions, there
3 are agreements in place for all these that we think
4 the DOE will address the issues. However, one thing I
5 think the staff certainly recognized that we aren't
6 going to reduce all the uncertainties in any area of
7 the TPA code, and uncertainty is something we need to
8 live with, and we think that we want to see a
9 treatment of uncertainty commensurate with its
10 importance to risk, and also a recognition that
11 information in the performance confirmation period
12 will continue to be collected and also will shed some
13 light on the uncertainty.

14 CHAIRMAN GARRICK: The issue is not to
15 eliminate the uncertainty, the issue is to quantify
16 them.

17 MR. McCARTIN: Yes, exactly. And what you
18 will see today is, really what I am trying to show is
19 that what we are trying to do is get a better
20 understanding of the uncertainties and possibly use
21 that to refine the agreements and help in our getting
22 ready to review a DOE license application.

23 (Slide)

24 With that, let me go to the first area,
25 which is the probability of an igneous disruption.

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1 Basically, in terms of the issue, estimating the
2 probability of disruption is related to how many
3 volcanoes are currently there from the past, and
4 looking at subsurface geologic features. Those are
5 two parts of, we believe, in estimating the
6 probability.

7 In terms of the NRC approach, we're using
8 the currently identified features from the past, and
9 that is approximately 13 events over the past 11
10 million years, and using subsurface geologic features
11 to better constrain what might be the probability of
12 disruption at the Yucca Mountain Repository.

13 Nevada is using a smaller subset of that.
14 They are using primarily volcanoes that have occurred
15 over the last million years comprising two to three
16 events. They use that in the defined particular
17 zones, some narrow zones that tend to focus on the
18 Repository.

19 MR. LARSON: Is that Cole (phonetic) and
20 Smith, or is it Smith and Kenno (phonetic), or who is
21 it?

22 MR. McCARTIN: With that, I'll refer to
23 Brit.

24 MR. HILL: This is Brit Hill, from the
25 CNWRA. That's the series of models from Smith, et.

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1 al., 1990, also a series from the Cole and Owen Smith.

2 MR. LARSON: Does this take into account
3 the recent work of Smith and his student Kenno?

4 MR. HILL: No, it does not.

5 MR. MCCARTIN: Notably, the zones are not
6 constrained by subsurface geologic features. DOE's
7 approach, they are constrained -- their probability
8 probably primarily on volcanoes over the last five
9 million years, that's approximately seven events.
10 They just define some broad zones, some of which miss
11 the Repository.

12 They also are not using geologic features
13 to constrain the probability.

14 MR. LARSON: Is that really right? Is
15 that really right? It seems to me that DOE's approach
16 does use geology in the sense that they are limiting -
17 - most of the source-zones are limited to crater flat,
18 and also they use topography, which is certainly, in
19 this area, part of the geological regime.

20 MR. HILL: Again, this is Brit Hill, from
21 the Center. When we say the zones are not bounded by
22 geologic features that localize volcanoes, we've
23 addressed the technical basis on why alluvium or small
24 topographic changes do not localize volcanoes, and are
25 restricted solely to the crater causation. And zones

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1 that are defined based on features that do not
2 demonstrably localize volcanoes are the ones that are
3 in many of the source-zones that bypass the
4 Repository.

5 I would also point out, in the PVHA
6 report, when the experts talk about how they define
7 the zones, they clearly do not make a linkage to
8 exclusive geologic features.

9 (Slide)

10 Now, with that, what does it mean
11 quantitatively in terms of where the various groups
12 are at, and the horizontal lines on the left are
13 depicting the range of probabilities that were seen
14 estimated by the three groups. You can see, State of
15 Nevada-sponsored work is somewhere in the 10^{-6} to 10^{-8} ,
16 NRC is around 10^{-7} to 10^{-8} , and the Department of
17 energy is somewhere -- a little bit of both, 10^{-8} down
18 to 10^{-10} . The Department's mean value is approximately
19 1.6×10^{-8} , which has it in that area of probability
20 space where it needs to be considered in terms of the
21 Yucca Mountain Repository, our probability cutoff
22 being approximately 10^{-8} .

23 CHAIRMAN GARRICK: Now, are they all using
24 the same time interval? I thought I heard you say
25 that Nevada was using a different time interval.

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1 MR. McCARTIN: Well, in terms of what are
2 the relevant events that they're using to determine
3 the probability, you're right. The easiest way to put
4 it, there's not an off-the-shelf thought to here's how
5 you determine --

6 CHAIRMAN GARRICK: So, these are not all
7 against the same database.

8 MR. McCARTIN: Correct. Well, people are
9 using different parts that they believe are more
10 relevant, and it is a matter of opinion. The
11 Department -- and I'll let Brit add anything -- but
12 the Department feels the most relevant events are
13 those in the last 15 million years, and they have a
14 basis for not including --

15 CHAIRMAN GARRICK: But this is such a
16 straightforward kind of question that we're asking
17 here, namely, the likelihood of the event. And it
18 would seem that you would not want to sweep any
19 knowledge under the rug that would shed any light on
20 the frequency of that event, of the recurrence of it.

21 MR. HILL: Brit Hill, from the Center.
22 First, a minor correction. The Department is heavily
23 focused on 5 million year and younger, not 15 million
24 year and younger.

25 MR. McCARTIN: Oh, I thought you said 15.

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1 MR. HILL: I wouldn't characterize it as
2 "sweeping it under the rug" or anything like that,
3 except a difference of opinion by what is the most
4 relevant in determining recurrence in the next million
5 to 10,000 years. Whether you are using a tighter
6 range of information because of your understanding of
7 process, how these were formed by the same process or
8 not, or believe that only the last million years is
9 the most important for the next 10,000 years --

10 CHAIRMAN GARRICK: Of course, the
11 discriminator here would preclude the need for asking
12 the question would be if we saw the probability of
13 distribution, we'd be able to see what the shorter
14 time interval meant in terms of the uncertainties
15 versus the longer time.

16 MR. HILL: Right, in trying to gauge a
17 model that's based on recurrence rates of 1 to 2
18 events per million years, and you think about space
19 and time, and then look at -- you're trying to focus
20 on a 10,000-year interval which is so much shorter
21 than anybody's recurrence rate. I can give you a
22 sense of why, for example, our position is that really
23 an order of magnitude construction of probability is
24 about all that's warranted because both the time
25 interval, sparsity of data, and the long recurrence

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1 doesn't warrant a large significant figure.

2 CHAIRMAN GARRICK: Well, the only thing is
3 that if it comes down to -- if it's a 10^{-7} value
4 that's important, and a 10^{-8} , or whatever the line is,
5 is not important, then it becomes more important to
6 turn up the microscope a little bit on the different
7 assumptions that are made about the input information
8 for the distributions.

9 MR. HILL: Just one final point. It's not
10 really the input assumptions that are driving this,
11 it's the alternative conceptual models. And whether
12 we want to take a single tendency from a series of
13 alternative conceptual models or not is not at all
14 clear at this stage.

15 CHAIRMAN GARRICK: Well, I didn't mean to
16 spend so much time on it, but I just wanted --

17 MR. LARSON: There really has been very
18 little -- very few attempts at this kind of prediction
19 until this problem came up, and the predictions were
20 either on a very short-term basis -- an ad hoc basis
21 of days, hours, months -- and the longer-term like
22 we're talking about has just not been approached. So,
23 we don't have standardized procedures -- I think
24 that's what Tim said, that we don't have standardized
25 procedures. And so while we're doing this job, we're

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1 trying to find those procedures.

2 CHAIRMAN GARRICK: The only thing I can
3 think that comes close to this is the frequency of
4 occurrence of very strong motion earthquakes.

5 MR. LARSON: Absolutely. There's a lot of
6 analogy there. In terms of short-term prediction
7 versus long-term prediction, these kinds of things,
8 this is the same problem, except that you have more of
9 an historical record with seismicity which gives you
10 a better chance of doing a decent job. And, also, we
11 understand that earthquakes are associated with
12 faults. Frankly, we have a really difficult time
13 pinning down what's really happening in the mantle
14 that's generating volcanic magmas.

15 Cognizant of your preamble, Tim, about not
16 getting into too much detail, but also recognizing
17 that you are talking about uncertainty, it strikes me,
18 when I see this diagram, I can recall during the PVHA
19 very lucid discussions of the NRC approach were made
20 by Brit and by Chuck Connor of the Center, and John
21 Trapp. I don't know whether I attended those or not,
22 it's been too long ago, but if I understand correctly
23 the results here and your previous slide, the ten
24 experts in volcanology that were selected by the DOE
25 to run -- to be involved in this expert opinion, chose

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1 not to accept the approach that is being used by NRC
2 today.

3 Can you understand the uncertainties that
4 develop as a result of this? Can we understand why
5 they failed to accept this? Does this cast any light
6 upon the uncertainties that we see not within NRC's
7 work, but between NRC and DOE?

8 MR. MCCARTIN: Well, in terms of between
9 NRC and DOE, I think it's -- in terms of -- I wasn't
10 involved in the PVHA either, so I don't want to talk
11 to that. I'll ask Brit to comment, if he'd like.
12 But, generally, this diagram here is showing the
13 variation of probability spatial based on the NRC
14 approach, and you can see the Repository loosely is in
15 this 10^{-7} - 10^{-8} range, and I think, obviously, these
16 aren't very -- you see variations in these isopleths,
17 and I think you're seeing the effect of structure,
18 which I think is useful in terms of new information
19 that could come in with the aeromagnetic data, but
20 you're seeing -- and I think Brit's right, in order of
21 magnitude, somewhere between 10^{-7} to 10^{-8} . From my
22 standpoint, I look at the DOE current number, 1.6×10^{-8} ,
23 they are in that same range -- I don't know if one
24 could say we're in that big a disagreement at this
25 time. And as I said before and you indicated, there

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1 is no textbook on how to do this, and there is
2 opinion, there is what-features-matter, et cetera, but
3 I don't know if Brit has anymore of what happened at
4 PVHA.

5 MR. LARSON: I just wanted to make the
6 point that -- and I do respect the NRC's approach and
7 people that are doing it very much, I respect them
8 very much, but I'm also struck by the fact that the
9 expert elicitation seems to disregard the NRC
10 approach, and I wonder where this is going to end up
11 when you come to some kind of judicatio on it.

12 MR. McCARTIN: One thing that at least I,
13 from my perspective and more PA rather than --
14 certainly, more PA than igneous -- but I think, as my
15 next slide will allude to, we're expecting to get new
16 aeromagnetic data that has been alluded, that there is
17 possibly 13 more identified events in the area.

18 When I look at what I've heard and my
19 limited knowledge --

20 CHAIRMAN GARRICK: Thirteen more, did you
21 say?

22 MR. McCARTIN: Yes, potentially --
23 potentially. It's still being evaluated, but it is
24 possible. Now, remember, you've got to look at the
25 time period, too.

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1 MR. LARSON: Yes, location and the timing
2 is everything.

3 MR. MCCARTIN: Is key, yes. But I think
4 when that information comes in, if I had to guess,
5 because of the fact that we use structure, subsurface
6 geology, to help constrain these numbers, I don't
7 believe the identification of those events will have
8 as big of an effect on the NRC estimate as it will on
9 potentially the State or DOE, and that's purely from
10 my very novice opinion, and does the NRC have a more
11 stable estimate because we have this other constraint
12 there that allows for -- this additional information,
13 depending on where it is, there are some bases. And
14 I don't know if Brit has --

15 MR. LARSON: But there was more than just
16 geological structure, I think it also had to do with
17 the length of the igneous dikes that were going to be
18 associated with it, and perhaps also the number, is
19 that correct? There's a difference between the NRC
20 approach and the PVHA approach.

21 MR. HILL: Again, this is Brit Hill, from
22 the Center. There are a number of questions that have
23 been raised. Going back to why the Center approach
24 wasn't used, I think it's just important to clarify
25 that the models that you see here that have geologic

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1 structure incorporated into the clustering algorithms,
2 those models were not developed by the PVHA, they were
3 subsequent to it. So, this really represents our
4 preferred approach was not available at the time the
5 DOE conducted PVHA in 1995, so there's been a
6 difference in the available models, first of all.

7 Second, to clarify on the aeromagnetic
8 anomaly -- of course, that is fairly new information -
9 - the U.S. Geological Survey just released until it
10 could file a report, an interpretation that says that
11 these anomalies that are shown on the figure in the
12 labeled letters are -- can be interpreted as varying
13 basalt. It's not just the location of those features,
14 but the age of those features that's going to affect
15 all models, not just the State and DOE's, but it may
16 affect ours as well. All assumed occurrence rate is
17 fairly uniform and doesn't cluster in time. Until we
18 have a better handle on the age, it's very difficult
19 to say what the effect could or could not be. But
20 taking a recurrence rate of seven volcanoes over 5
21 million years to 20 volcanoes for 5 million years
22 could have a significant effect on any probability
23 model.

24 MR. LARSON: Can I ask another question?

25 CHAIRMAN GARRICK: Sure.

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1 MR. LARSON: Going to this aeromag survey
2 -- and certainly it very much bears on the uncertainty
3 -- has the NRC considered the number of possible
4 basaltic features that might have been uncovered if
5 that survey had been flown with the specifications
6 appropriate for a survey designed for detecting these?
7 This aeromagnetic survey was conducted to map
8 hydrologic features. It was flown in a direction in
9 which you cannot adequately map dipolar features that
10 are small -- and I've written to you about that in a
11 report -- and, also, if this is so important to
12 determining the igneous concerns, why isn't this
13 magnetic survey extended into other regions, to the
14 north and to the east? There is a 300,000 year old
15 volcanic feature to the northwest, off of -- called --

16 MR. HILL: Thirsty Mesa.

17 MR. LARSON: -- Thirsty Mesa, thank you.
18 This survey doesn't go up into that area. If this is
19 so important, why aren't you pushing to get
20 appropriate data to do the job?

21 MR. McCARTIN: Once again, Brit will have
22 to answer that. However, what we're trying to do here
23 is give you a sense of the differences between
24 ourselves and DOE, and we certainly can go into that
25 detail, but Brit is going to have to answer that

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1 question.

2 MR. HILL: Well, we had looked at
3 available information at the time, and thought that
4 the Cain and Bracken (phonetic) survey, the existing
5 aeromagnetic data, we had evaluated that and, as you
6 are aware, conducted a series of ground magnetic
7 investigations to look for potentially varying
8 characteristics, and we felt that with the available
9 information we didn't have a significant concern. Now
10 we're seeing new information from this aeromagnetic
11 survey. And I agree, it was not flown designed to
12 look for these features, but it was a target that
13 provided the Department a chance to mine the existing
14 data and come up with new characterization
15 information. Now we have the report, and it's raising
16 some very potentially significant concerns about how
17 many features, varied igneous features -- it doesn't
18 mean intrusive, necessarily, it could be buried
19 volcanoes -- really are within an area that could
20 affect our understanding of the probability.

21 MR. LARSON: Does that open up then other
22 areas for further investigation based upon what you're
23 seeing here?

24 MR. HILL: We're going to have to have
25 discussion with the Department of Energy fairly soon,

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1 once we've had a chance to evaluate the open final
2 report that came out last week, but this is the
3 preliminary interpretation, which is also part of the
4 technical basis impact weather report where the
5 preliminary interpretations were that there were
6 additional features, but they would not affect
7 Department of Energy probability models.

8 MR. LARSON: Well, if you find all these
9 to the south and west of the Repository, I just wonder
10 what's up there to the north and west, because we do
11 have one that certainly falls within the time span of
12 anyone's evaluation of the volcanic processes in the
13 area.

14 MR. HILL: We're very concerned about
15 noisy terrain both adjacent to or east of the
16 Repository as containing present but undetected
17 igneous features.

18 CHAIRMAN GARRICK: Tim, this is something
19 -- do these numbers within these contours, say, the
20 10^{-7} to 10^{-8} , do they reflect your uncertainty about
21 the likelihood, and is that all informational as
22 opposed to modeling?

23 MR. MCCARTIN: Well, in this area,
24 certainly these are related to models that the Center
25 has used, and there's variation within those models.

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1 In terms of whether modeling uncertainty or
2 uncertainty of another kind, I think Brit has to talk
3 to variation there.

4 MR. HILL: A very good answer is that the
5 uncertainty in the parameters, and also alternative
6 conceptual models. It does not capture the model
7 uncertainty. We have not evaluated quantitatively the
8 uncertainty in each probability model and factored
9 that in as an uncertainty.

10 CHAIRMAN GARRICK: Right, because this
11 suggests a pretty high level of certainty.

12 MR. HILL: We did not overinterpret each
13 line being a solid line that's fixed to the ground.

14 CHAIRMAN GARRICK: That's the only reason
15 I asked the question, don't want to do that.

16 MR. LEVENSON: Tim, I have a question.
17 Just because somebody wrote the words down forces me
18 to ask the question. In the Center review of DOE's
19 elicitation of expert opinion was criticized for what
20 ten people said greater balance is needed on the panel
21 to encompass a wider range of viewpoints, and also
22 potential conflicts of interest. Is the same
23 criticism potentially applied to inhouse version?
24 You'd probably have less than ten people.

25 MR. McCARTIN: Well, we certainly had less

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1 than ten people. That's -- I'm not sure how to answer
2 that question.

3 MR. LEVENSON: I wouldn't have raised the
4 issue, but you people raised it.

5 MR. MCCARTIN: Right. I mean, there's a
6 difference in looking at DOE, what they need to do to
7 provide this information. We certainly are working to
8 develop our own understanding here -- and I'll get to
9 you in a second, Brit, I know he wants to add
10 something here.

11 We have gone for peer review and outside
12 review of what we've done. We certainly have not done
13 a separate expert elicitation.

14 MR. HILL: We have not held our work out
15 as an expert elicitation. We put it as expert
16 judgment, and we put it in peer review literature, but
17 we have not tried to portray this as a consensus.

18 MR. LARSON: Well, I don't want to come to
19 anyone's defense here. God help me, I don't want to
20 do that. But I sat in on some of the reviews of --
21 for the peer reviews of the Center's work, and
22 although there were problems, there was general
23 consensus that this was really headed in the right
24 direction.

25 In addition, when many of their

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1 publications came up for review, I happened to be
2 editor of the Journal and they fell in my lap, and I
3 don't think I've ever given anything as tight a review
4 as the papers that came in from the Center. Instead
5 of having two, three reviewers, they had five or six,
6 including members of the DOE staff. So, I think that
7 this has been looked at by the public and been pretty
8 well received.

9 CHAIRMAN GARRICK: Is that articulated in
10 your database and in your supporting information, what
11 Bill just described?

12 MR. HILL: I'm not sure what you mean by
13 supporting information.

14 CHAIRMAN GARRICK: Well, that's pretty
15 valuable evidence, it seems to me, what he just
16 described.

17 MR. HILL: It's not part of the record.

18 MR. McCARTIN: In general, though, our
19 approach has been to make sure DOE -- what information
20 do they have to bring forward to support so that we
21 can review their license application?

22 (Slide)

23 Continuing -- hopefully I'll be able to
24 pick up the pace.

25 CHAIRMAN GARRICK: That's not your

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1 problem.

2 MR. McCARTIN: In terms of probability,
3 we've pretty much discussed this quite a bit. As I
4 said, the new aeromag data is coming in. From a risk
5 standpoint, what we see now is there's an
6 approximately an order of magnitude difference in the
7 probability between ourselves and DOE.

8 MR. LARSON: DOE keeps talking about their
9 probability assessment as being very robust, and I
10 think perhaps if we asked you, you'd say the same
11 thing.

12 What's going to happen with -- let's say
13 that just a few of these anomalies are volcanics that
14 fall within a range of distance and time that are
15 interesting. What's this going to do to 10^{-7} , 10^{-8} ?
16 What are we worried about? Are we so -- is this whole
17 approach so fragile that finding another volcano or
18 two is going to send this catapulting to an even
19 higher probability?

20 MR. McCARTIN: Well, as indicated here, if
21 you ask for a best-guess at the moment, we're looking
22 at a 2 to 5 times increase in probability.

23 MR. LARSON: On the basis of 13 more
24 volcanoes in their position, in their place, as you
25 have them? So you analyzed them?

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1 MR. McCARTIN: Well, what we're trying to
2 do is give you where we're at today and where we think
3 things may end up. And to say -- I mean, I don't
4 think we want to be held firmly to anything here, but
5 trying to give you an informed estimate that's where
6 we think it might end up.

7 Is that a big deal? I think what I'd like
8 to do is look at all the uncertainties we have and
9 look at it from that standpoint.

10 MR. LARSON: But, Tim, this is really the
11 critical uncertainty. The DOE oftentimes approaches
12 this, and many people approach this, from the
13 standpoint that you're multiplying zero times any
14 number is still going to be zero, and such a low
15 probability -- the probability is the backbreaker on
16 this.

17 MR. McCARTIN: Well, in one sense. I
18 don't believe that's so much the case currently, and
19 for this reason, that if it was below 10^{-8} and now
20 we're looking at a decision to whether it's considered
21 or not considered and it's screened up, that's not the
22 case. Right now, DOE is, like I said, approximately
23 1.6×10^{-8} , so it's being considered.

24 And at least from my standpoint, not
25 looking at whether it's probability or some other

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1 factor, if the estimate -- clearly, if the probability
2 increases by a factor of 5, it does increase the
3 overall risk by a factor of 5, but there are many
4 other aspects of the calculation that have similar
5 effects, either raising it or lowering it. And so
6 this is one of those factors, but if it were not in a
7 position of whether it's considered or not considered
8 -- and that's where I think the critical aspect was.
9 Whether it's 10^{-8} or 10^{-7} , I don't think is as critical
10 as it's going to be considered or not going be
11 considered, at least from my perspective.

12 CHAIRMAN GARRICK: Tim, we're sorry to
13 press you the way we are.

14 MR. McCARTIN: No, no. It makes it more
15 interesting for me.

16 CHAIRMAN GARRICK: Let me ask this
17 question. Supposing that the TSPA/LA comes out with
18 a much more robust analysis that shortens the time to
19 the peak dose dramatically, as well as the magnitude,
20 and we already see scenarios where the peak dose time
21 varies from a few thousand years to a million years,
22 and it is swung dramatically by certain parameters
23 and certain performance characteristics, such as
24 actinide solubility and -- so, if it turns out that in
25 the license application or in the analysis that's

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1 going on now that's a follow-on from the SSPA, that
2 this dose drops down and the time at the peak dose
3 shortens dramatically, does that impact the
4 significance of the 10^{-7} ?

5 MR. McCARTIN: In terms of -- you're
6 saying if the base case dose shortens and --

7 CHAIRMAN GARRICK: Yeah. It's one thing
8 to talk about recurrence of the order of 10^{-6} , 10^{-7} ,
9 when you have a situation where the worst part of the
10 problem is of that same order in terms of time, but
11 it's another thing when that time dramatically
12 shortens as well as the magnitude of the dose. And
13 I'm just asking if the performance calculations change
14 dramatically, does that change the significance of the
15 recurrence interval for igneous activity?

16 MR. McCARTIN: Well, I guess I still have
17 to ask, with respect to the base case, you're saying
18 that the base case scenario occurs much earlier --

19 CHAIRMAN GARRICK: Yeah.

20 MR. McCARTIN: -- so that there's not --

21 CHAIRMAN GARRICK: I'm saying if they come
22 forward with --

23 MR. McCARTIN: -- would they add together
24 rather than be separated in time?

25 CHAIRMAN GARRICK: -- yeah, one in ten

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1 million year event, how significant is that when now
2 you're talking about something of the order of 10^{3rd}
3 years and a much lower peak dose? It seems to me that
4 you've got to reassess the significance of --

5 MR. McCARTIN: I think that the
6 information that DOE will give us, we'll be able to
7 see what the base case results -- what the disruptive
8 ones are. The Commission will have to weigh that in
9 terms of what does that mean, if these two are
10 additive and now they are slightly above the standard.

11 CHAIRMAN GARRICK: Now, picking up on
12 something that Bill said earlier alluding to the fact
13 that the DOE has come forward -- feels that their
14 recurrence interval calculation, their probability
15 calculation is very robust, and yet they have kind of
16 caved in to the NRC number. Does that make sense?
17 Have they been able to -- have you been able to
18 demonstrate to them that your number is comparably
19 robust and that's why they chose to do this?

20 MR. McCARTIN: Well, in this particular
21 area, there is an agreement that the DOE can come
22 forward with a license application with their
23 probability number.

24 CHAIRMAN GARRICK: Oh, I see.

25 MR. McCARTIN: They have agreed to also,

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1 as the sensitivity analysis, to include analysis with
2 the 10^{-7} value, to provide that additional
3 information, but it's sort of a two-prong kind of
4 thing.

5 CHAIRMAN GARRICK: Okay.

6 MR. HILL: Just perhaps one very brief
7 point, the reason that we have that agreement is
8 because at the staff level we had fundamental
9 disagreement with the robustness of DOE analysis.

10 CHAIRMAN GARRICK: That's what I was
11 curious about.

12 MR. HILL: In August of 2000, we had a
13 technical exchange that seemed like we were really in
14 a fairly impractical position on several of the
15 issues, and determined that if we got the analysis as
16 part of the TSPA/SR and TSPA/LA we agreed would have,
17 in our view, an adequate basis at 10^{-7} at that time.
18 That would provide us with enough information to reach
19 a licensing decision, and we would not need to move
20 the issue forward, but it's more that this was to
21 address specific technical concerns at that time.

22 CHAIRMAN GARRICK: See, I have a --

23 MR. HILL: It was not a matter of we were
24 just insisting on this number for some unspecified
25 reason.

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1 CHAIRMAN GARRICK: Yeah. See, I have an
2 ulterior motive here. I'm trying to extract from this
3 whole process how much of it is compliance-driven and
4 how much of it is risk-driven.

5 MR. McCARTIN: In terms of the path
6 forward, there's really two parts of it. The second -
7 - that last part we've talked about enough, the 10^{-7}
8 value that DOE will use, but the first part -- I think
9 both ourselves and DOE will be analyzing the
10 aeromagnetic data and updating estimates, and I think
11 including uncertainty is a key part of that, that I
12 think one of the things we'll be looking at, does it
13 make sense to have a single value, or should we be
14 sampling from a distribution --

15 MR. LARSON: Does that mean that DOE will
16 go beyond the report that was published this year, of
17 the USGS? Is Los Alamos continuing their work on
18 this?

19 MR. McCARTIN: Well, right now DOE, I
20 think, is updating a lot of their plans and what they
21 are going to accomplish, and when. And I don't know
22 if I want to try to speculate what DOE is going to do.
23 I assume they will analyze this information, but in
24 what time frame and how, I don't know. We would
25 expect to analyze -- to speak more for ourselves, and

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1 I put 2002 there -- we're going to analyze this
2 information this year. I would expect DOE to do the
3 same but, like I said, they are updating their plans.

4 (Slide)

5 I finally got off probability.

6 CHAIRMAN GARRICK: That was the easy one.

7 MR. McCARTIN: Uh-oh, I'm in trouble. In
8 terms of getting in more now to the consequences in
9 terms of the Repository magma interactions, the issue
10 is one of when magma rises up and there is a drift,
11 there's obviously a path there that it can take down
12 the drift, and the question is one of what's going to
13 happen in terms of an alternative pathway. Rather
14 than continuing straight up to the surface, the magma
15 goes down the drift and breaks out at some more
16 distant part, thereby intercepting more waste
17 packages. And so it has to get to how many waste
18 packages are intercepted in the event.

19 Alternatively, the NRC approach, we still
20 have a single vertical conduit, 1 to 10 waste packages
21 are intercepted, it depends on the diameter of the
22 conduit, on average 5 waste packages. However, there
23 are these numerical experiments and calculations being
24 done to look at what happens when the magma hits the
25 drift, and there are evaluations for that at the

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1 current time we are looking at it is on average. It
2 could be as high as 100 waste packages, depending on
3 some assumptions in terms of how far down the draft
4 things go. But if we represented today this
5 alternative, you'd be looking at approximately 100
6 waste packages versus the 5.

7 DOE has a very similar approach right now
8 of looking at a single conduit up through the
9 Repository. They sampled somewhere between 3 to 30
10 waste packages, a median value of around 10, as part
11 of this vertical conduit. They have agreed to look at
12 this alternative approach. We haven't seen any of
13 their analysis related to this, but that's part of the
14 --

15 MR. LARSON: Is the alternative approach
16 only for dikes, or is it for a pipe?

17 MR. McCARTIN: Well, if the dike comes up,
18 intersects the drift, the Repository drifts, and then
19 the question, where does the conduit form? And it's
20 the dike actually that's intercepting the drift, and
21 could intercept multiple drifts, which is how we get
22 the possibility for 100 waste packages, and it is on
23 average 2 drifts are intercepted and where conduits
24 form.

25 MR. LARSON: Maybe the committee knows

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1 this already but, if not, just what is NRC doing in
2 this area at this time, have you people learned that?
3 Do you know what --

4 MR. McCARTIN: Well, I thought in August
5 Brit Hill gave a presentation to the committee in
6 terms of the -- both there are numerical calculations
7 going on with laboratory experiments, analog
8 experiments, to try to corroborate the numerical
9 calculations. I don't know if Brit wants to add to
10 that at all, but --

11 MR. HILL: We also went over this last
12 month.

13 CHAIRMAN GARRICK: The one thing that has
14 always been difficult for me to understand, and not
15 being an earth scientist, it's not difficult to
16 understand why I don't understand, but it's one thing
17 to get these recurrence intervals on the basis of the
18 kind of data we've been talking about, but what do you
19 use to establish your insights on pathways and depths
20 and magma flow and what have you? Where do you get
21 that information? How do you get that information?

22 MR. HILL: There's a lot of sources of
23 information. At first, we are strongly based on an
24 analog approach where we looked at similar volcanoes
25 that have been recently active. Second, on the flow

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1 pathways, we're taking a stronger numerical and analog
2 experimentation approach because we can't go down 300
3 meters and look at these sorts of conditions. And
4 it's unprecedented that ascending magma has
5 intersected a horizontal void of any extent at these
6 kind of depths. We hear a lot of tubes, but they are
7 very, very shallow, and so you don't have the same
8 sort of depressurization and flow phenomenon that you
9 would expect down at 300 meters. That's in part why
10 we've been doing a lot of the experimentation and are
11 talking about this year continuing with fluid dynamic
12 flow experiments to better look at this kind of a
13 process at the appropriate scale for fluid containing
14 a lot of gas. But there really is a lot of
15 information out there on how normal volcanoes of
16 similar composition and volume and character, how the
17 volcanoes erupt in nature. We can glean an awful lot
18 of the physics and fluid dynamics just by very
19 straightforward observation and simplified modeling.
20 And, remember, we're talking about a pressurized fluid
21 intersecting an atmospheric void.

22 CHAIRMAN GARRICK: Right. And I guess the
23 issue of backfill comes into this in a significant
24 way.

25 MR. HILL: Certainly.

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1 MR. McCARTIN: From a risk standpoint,
2 obviously we are looking at an approximate order of
3 magnitude, when you look at 1 to 10 waste packages, of
4 up to 100 on average.

5 In terms of what's going to go on to move
6 the path forward, DOE -- we're expecting them to
7 analyze this scenario and come to some conclusions.

8 From NRC's standpoint, as Brit indicated,
9 we are continuing with the numerical analyses in some
10 of the experiments. In September of this year, we
11 expect to have some additional information on
12 verification of the model and the experiments, and as
13 you indicated, backfill, and that's exactly what this
14 last tic is, looking at the consideration of
15 Repository design in terms of how this impacts the
16 number of packages that could be affected. Backfill
17 certainly has a big impact. Right now, the design is
18 not to backfill the drifts, but the access tunnels, et
19 cetera, would be backfilled, and that has some
20 implications.

21 MR. LARSON: Are you having any peer
22 review of the work that you are currently doing,
23 verifying the numerical models and the analogs, the
24 laboratory analogs?

25 MR. McCARTIN: A couple of them. Well, I

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1 guess it was about two years ago we had -- well, some
2 might call it a peer review, we certainly brought in
3 a number of different experts in different areas to
4 review what we were doing with the TPA code, and got
5 review comments, et cetera -- maybe an expert review
6 rather than a peer review. And certainly the Center,
7 as a group, tries to publish in a number of journals.
8 NRC staff did the same thing, and so we continue to
9 publish. I don't know if there are any explicit plans
10 for any specific review of a particular topic.

11 MR. HILL: The publication is to elaborate
12 very briefly. We've been having trouble getting the
13 two reports that we talked about earlier last year,
14 getting those reports accepted for review because the
15 topic is deemed too esoteric to appear in Geological
16 Journal. So, we have yet to receive --

17 CHAIRMAN GARRICK: I knew these scientists
18 were stuffy.

19 MR. HILL: But we're continuing to
20 resubmit to different journals that have a little more
21 dynamic approach. Of course, this has been presented
22 at international meetings like the American Geological
23 -- or American Geophysical meeting.

24 MR. LEVENSON: Tim, I have a question in
25 the context of trying to move toward risk-informed.

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1 There's a statement in the report here that "Staff
2 concludes that the character of past YMR igneous
3 activity represents the most conservative bounds on
4 future YMR activity". That most conservative, 1 order
5 of magnitude, 3 orders of magnitude?

6 MR. McCARTIN: I guess I'm not -- what
7 report is that?

8 MR. LEVENSON: That's the Center's report
9 on --

10 CHAIRMAN GARRICK: It was in our briefing
11 book.

12 MR. LEVENSON: -- our briefing book. I do
13 read the junk you send us. It's Technical Basis for
14 Resolution of Igneous Activity.

15 MR. McCARTIN: I'd be happy to take that
16 page down and -- I can't --

17 MR. LEVENSON: I'm really asking a generic
18 question. I get nervous whenever people say, "Well,
19 that's very conservative, so it's okay". I mean, is
20 it a factor of 2, is it a factor of 100?

21 MR. McCARTIN: Well, partly, what I'm
22 trying to do in going through this is give sort of
23 where things could end up, and I will talk to that,
24 but the approach we're trying to do and part of what
25 this is as a result of, we're looking at the

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1 information that we have, what we're using to estimate
2 the consequences, and how we might improve things to
3 get a more realistic approach.

4 We certainly are not trying in any area of
5 the TPA code to take the most conservative approach.
6 I'm not -- those words trouble me, I guess, because
7 it's not clear on the context --

8 MR. LEVENSON: It isn't clear from here
9 whether it's the NRC staff that did that analysis or
10 what, you can't tell who did that. This is the staff
11 commenting on it.

12 MR. SINGH: I'm not sure if that's been
13 issued to -- sounds like it's still being reviewed.

14 MR. LEVENSON: I'm sorry, go ahead.

15 (Slide)

16 MR. McCARTIN: In terms of the magma-waste
17 package interactions, clearly, when a hot magma
18 interacts with a waste package, we're talking about a
19 -- certainly, in the conduit, a fairly violent
20 interaction. Physically, chemically, thermally, these
21 conditions are quite extreme.

22 So, the question is how does the package
23 act in this environment? In terms of the NRC, for the
24 extrusive amount, the package is in the conduit.
25 We're assuming the package offers no protection from

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1 the spent fuel from the magma. And so it's as if
2 there is no package.

3 MR. HILL: Just to answer the previous
4 question about the character of Yucca Mountain
5 volcanoes conservatively, that's specifically to
6 address that we do not believe that magma water
7 interactions would create a different class of
8 volcano, and that there is no other class of volcano
9 of this composition that would give a more dispersive
10 eruption, which is the process that was discussed in
11 that section. So, the past character would bound the
12 dispersivity and fragmentation capability, and that
13 any other -- trying to say that they're less
14 dispersive would be a less conservative approach.

15 MR. McCARTIN: In terms of the intrusive
16 amount, we have on average in our code approximately
17 40 waste packages failing, and just assume, once
18 again, if magma contacts those waste packages, it will
19 fail the container. Part of it is due to the
20 temperatures. The magma is approximately 1100
21 degrees, et cetera, and the drifts are unbackfilled.
22 This really does not account, at this time, for this
23 alternative flow path. It could be more packages if
24 we looked at that alternative flow path. We have not
25 worried about varying that. We believe that's a very

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1 small contribution to the overall risk, and you'll see
2 that actually is a slight difference between ourselves
3 and DOE.

4 In terms of the DOE approach --

5 MR. LARSON: Excuse me, Tim. Is that then
6 all taken -- enters into the biosphere through
7 groundwater?

8 MR. McCARTIN: It has that possibility,
9 yes.

10 MR. LARSON: But only --

11 MR. McCARTIN: Only -- yes, it is
12 intrusive, yes, absolutely. For the DOE approach,
13 they have a similar approach for the extrusive. Any
14 waste packages in the conduit don't have any effect of
15 limiting the entrainment of spent fuel in the magma.

16 In terms of the intrusive, they have a
17 slightly different approach. They have two zones.
18 Zone 1 where the package offers no protection, also
19 similar to ours, and in that zone right now they have
20 approximately 200 waste packages. And then there is a
21 Zone 2 where they have what's called some "end-cap"
22 failures, some moderate failures of the waste package.
23 And they have, on average, 2,000 waste packages there,
24 a significant amount more. And that is a big
25 difference between ourselves and DOE. They have far

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1 more -- they get a larger intrusive release than we
2 do. However, even if we increased our number of waste
3 packages, we would not get, I don't believe, get to
4 the numbers that DOE has, and that's something that
5 you'll see in terms of the path.

6 CHAIRMAN GARRICK: Well, what they gain on
7 their probability, they lose on their consequences.

8 MR. McCARTIN: That's one way to put it,
9 for intrusive. That's the intrusive -- yes.

10 (Slide)

11 And that's part of the risk insight here.
12 We understand that the intrusive is a very low
13 fraction of the extrusive, and so we have not
14 concentrated much effort on that particular part.

15 Conversely, DOE has the intrusive a much
16 larger fraction. Until recently, the intrusive was
17 the larger dose contributor. In the SR, intrusive was
18 a larger dose than the extrusive. That has
19 flipflopped, but it is still a very high percentage of
20 the extrusive.

21 CHAIRMAN GARRICK: Now, have you seen the
22 analyses that they performed where they assume these
23 2,000 waste packages?

24 MR. McCARTIN: Yes, that's the SSPA.

25 CHAIRMAN GARRICK: So you're able to pin

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1 it down as to the fundamental difference between the
2 NRC analysis and the DOE analysis?

3 MR. McCARTIN: Qualitatively, I believe
4 so. I'm not convinced. I mean, that's one of the
5 things, path forward, that this last -- this year, I
6 promise you, we will understand those differences. I
7 think they're -- at a very broad level, I believe
8 there is approaches in terms of the release, in terms
9 of their diffusional release, that when they go to
10 this igneous scenario where they fail the waste
11 package, I believe they give some very, very large
12 diffusional releases, and that's part of it.

13 There might be some ways that they are
14 using the probability to weight things that we don't
15 quite understand how they are doing it. They have a
16 slightly different approach to weight the consequences
17 with a probability than we do, and there are some
18 other aspects to the calculation. We are digging into
19 it. We don't have the answer. This year, we will.
20 I think part of it is we need to get a little smarter,
21 look a little deeper into the DOE calculations, and
22 ultimately we will end up with probably an Appendix 7
23 or some other type of meeting with DOE to go over,
24 okay, here's how we understand your representation.

25 As you know, I've mentioned this before,

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1 diffusional -- one simple thing to point to is
2 diffusional. Ourselves, and DOE, for the base case,
3 have approximately the same releases for completely
4 different reasons. We take no credit for cladding,
5 but we have no diffusional releases. We did an
6 estimate and saw that diffusional releases were such
7 a small fraction of the invective releases that we
8 don't have diffusional release.

9 DOE, on the other hand, takes a lot of
10 credit for cladding, and has a diffusional release
11 that dominates over their invective release,
12 approximately an order of magnitude, and I think we --

13 CHAIRMAN GARRICK: Particularly for long-
14 term effects.

15 MR. McCARTIN: Yes. And in the situation
16 for volcanism in the intrusive, I believe for those
17 200 waste packages they take no credit for cladding
18 and no credit for the waste package, and so they have
19 some very, very large releases. I think that's at the
20 heart of it, I'm not certain, but there's an aspect of
21 taking in and understanding this better that we
22 certainly are in the process of doing. I'm very
23 confident this year we will have an answer to that.
24 To me, from a performance assessment standpoint,
25 that's the most fun this job brings, is trying to

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1 uncover a mystery. We have a mystery here we don't
2 quite understand, and technically it will take a
3 little bit of work, but I think that's the fun part.

4 CHAIRMAN GARRICK: Andy.

5 MR. CAMPBELL: Tim, are there any examples
6 of magma interaction with features at all? The reason
7 I ask is, if I understand correctly, basically, once
8 a waste package "fails", for all intents and purposes,
9 it is not there.

10 MR. McCARTIN: Right.

11 MR. CAMPBELL: And you haven't talked
12 about waste form interactions, but essentially you
13 assume a significant fraction of the waste form
14 becomes a very small particle. Is there anything that
15 can be gathered in terms of interactions with engineer
16 features or wall rock interactions that can constrain
17 these kinds of models?

18 MR. McCARTIN: Certainly, there's wall
19 rock interaction. On here, we are going to try to
20 look at the literature for analogous kinds of
21 situations, and it's primarily the Center is going to
22 be helping us, try to see are there things that we can
23 draw some parallels. It's not easy, and I don't know
24 if Brit has any other ideas, but we're going to try to
25 look at that in a data-poor situation and try to find

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1 some additional information -- I know Dick Codell is
2 trying to look at are there some reactor accidents,
3 like TMI, where maybe there's some information more in
4 the fuel area, can you glean some information in an
5 area where you have very little, but we are going to
6 try to pull in information where possible.

7 MR. LEVENSON: There is data from
8 Chernobyl, both the U.S. models and the Russian models
9 predicted that the molten core would certainly go
10 through the floor down, and it didn't penetrate the
11 floor anywhere. The molten fuel ran for long
12 distances on the top of floors, and then poured down
13 through existing holes, and all of the models were
14 incorrect in their projections, both U.S. models and
15 Russian models.

16 MR. HILL: To directly answer your
17 question on engineering analogs, the answer is no.
18 There is no experience of having a basaltic volcano or
19 any volcano erupt directly through an engineered
20 facility. And, remember, we're talking about putting
21 a waste package into an erupting volcano, not on top
22 of a lava flow. So, there is a long-range of
23 physical, thermodynamic process that's involved in
24 this, and exactly modeling what's going to happen as
25 we go from highly reducing environment at temperatures

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1 of about 1100° C. under very high dynamic flow, the
2 best I can tell you is that this starts off as a 1
3 meter wide dike and reams out the wall rock on the
4 order of 10s of meters in diameter, through
5 overpressure-underpressure relationships, so there is
6 sufficient force, sufficient work to essentially at
7 times melt or disaggregate solid rock.

8 And just a clarification on some of the
9 Chernobyl information, I believe the temperature for
10 the fuel to become molten is about 2000° Centigrade,
11 there's some very high temperature beyond what we have
12 been seeing in igneous events, or well below the
13 solubleness for incorporation in basalt, but we're
14 dealing with, again, a process where at the point of
15 initial incorporation where a highly reducing
16 environment of producing these are very low, on order
17 of 10⁻⁹ atmospheres, but as we go up into the erupting
18 cloud, we're going -- mixing with the atmosphere very
19 rapidly, at temperatures on the order of several
20 hundred degrees Centigrade. And one analogy we have
21 drawn from the Chernobyl accident is a very rapid
22 oxidation and formation of secondary oxide phase and
23 embrittlement of fuel particles during these complex,
24 rapid geochemical mixing events. We are continuing to
25 work with people like Dick Codell and other folks that

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1 have a much better background in waste forms to try to
2 glean some things from these reactor accidents to look
3 at more mechanically how would the fuel aid during an
4 event, but we're dealing with very rapid changes of
5 very high dynamic load on all of the waste packages
6 waste forms.

7 CHAIRMAN GARRICK: Just in that
8 connection, what do you assume about the deposition of
9 the radionuclide inventory in the magma, is it just
10 instantly available?

11 MR. McCARTIN: There's an incorporation
12 ratio that picks it up.

13 MR. HILL: And we're looking at a process
14 of conduit-widening right now where the waste package
15 is heated up for ambient conditions up to about
16 magmatic temperatures, and the internal contents are
17 heated as well, so we're going to have cladding
18 degradation, oxidation --

19 CHAIRMAN GARRICK: So there is a process.

20 MR. HILL: It's process-driven, but it's
21 not mechanistic because there are so many
22 uncertainties about how would this feature behave. We
23 faced early on the dilemma of, well, guess, it's not
24 instinct, would it be 100 percent efficient? Probably
25 not, except if I look at holes in the ground from

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1 volcanoes, they're 100 percent efficient in
2 lightening. But how would I get a technical basis to
3 say it's 80 percent or 70 percent efficient? How
4 would I defend that?

5 CHAIRMAN GARRICK: So it's just one of the
6 many abstractions that are involved.

7 MR. HILL: It's a complex abstraction,
8 that is a simplification, but it is based on the
9 unusual mass and mechanical loads that are inherent in
10 this system, analogous for a reactor loci than any
11 sort of storage type accident.

12 CHAIRMAN GARRICK: Thank you.

13 (Slide)

14 MR. McCARTIN: Going to the fuel, along
15 the similar lines, but certainly once again the
16 chemical/thermal aspects of the magma are going to be
17 a harsh environment for the fuel. Right now, NRC has
18 a fairly simplified approach -- it's an incorporation
19 ration in that particles -- in simple form, particles
20 that are larger than the spent fuel particles can
21 incorporate that smaller particle.

22 DOE has adopted a similar approach.

23 MR. LARSON: Does that take into account
24 the density of the -- the high density of the fuel?

25 MR. McCARTIN: Yeah.

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(Slide)

In terms of the risk insight, there's a lot of uncertainty here, as Brit was describing, exactly how is this fairly violent eruption, as its pushing through the conduit, interacts with the fuel. Certainly, you can do some further refinement, but our gut feeling is that the refinement would not result in a significant change. Right now, 100 percent of the fuel is incorporated. Is it 80 percent? Is it 50 percent? You might have to do a lot of work to get a little more resolution on that, and we're not convinced you could get it down very low, but that's a gut feeling. Certainly, our path forward this year, we're looking at refining our source-term model in that sense. Once again, as was mentioned, we're going to try to evaluate the relevant reactor accidents possibly. Maybe there's some information there that will help us.

And the bottom line is, DOE does need to develop a technical basis for this. This is one area where I know they have adopted our model. Merely adopting the NRC model is not a technical basis. Just because it's our model doesn't mean it's necessarily supportable. The DOE needs to do some work to at least convince themselves that it is a reasonable

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1 model, not just because it's the NRC's.

2 MR. LARSON: Are you evaluating more
3 complex repositories that simply are a tube? Are you
4 assuming any distortion of the tube? Any rock falls,
5 and backfill?

6 MR. McCARTIN: In terms of the alternative
7 pathways?

8 MR. LARSON: Right.

9 MR. McCARTIN: Yes. That was part of the
10 repository design, you look at backfill. But we also
11 are looking at, over time, you'll have rockfall and
12 accumulation of material in the drifts.

13 MR. LARSON: If I understand the process
14 here, what you would end up with is the canisters that
15 are being opened up being pushed to some portion of
16 the drift. Are you evaluating the effect of that, of
17 a concentration of the fuel on the thermal aspects of
18 the surrounding rock? You know, if we're going after
19 a low temperature repository, we'd push all of the
20 magma -- or all of the fuel into one end, we've
21 changed that process.

22 MR. McCARTIN: Yes. The initial
23 calculations were assuming empty drifts, and
24 subsequent ones are looking to refine things -- and
25 Brit can talk to the later work.

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1 MR. HILL: Right. The initial scoping
2 report back in 1999 talked about the possibility of
3 the initial shock being sufficient to move waste
4 packages. In the Woods, et. al. paper, we've refined
5 that approach with a little more added, and do not
6 believe that you have either enough friction or
7 velocity to move a waste package.

8 MR. LARSON: So, a lot of simplifying
9 assumptions.

10 MR. HILL: We're not seeing things like
11 moving down the drift, the waste package remains
12 intact even under the range of flow conditions in the
13 Woods, et. al. report. So that was an initial model
14 that turned out to be --

15 MR. LARSON: So there will be no
16 concentration of the fuel in any portion of the
17 drifts?

18 MR. HILL: Not during the initial stages
19 of flow because you cannot move an intact cold waste
20 package under the conditions that we currently realize
21 as reasonably bounding the expected upper range of
22 flow during that initial impact.

23 CHAIRMAN GARRICK: You can't have it both
24 ways.

25 MR. HILL: Another thing is, we haven't

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1 looked segregated flow during sustained eruption.
2 After the waste package is disaggregated, it's
3 possible you could get a concentration zone between a
4 low velocity and high velocity horizontal flow, but I
5 don't think that's likely given the turbulence
6 inherent in the system. However, we haven't analyzed
7 it, but plan to analyze it in the coming year.

8 MR. LARSON: Thank you.

9 (Slide)

10 MR. MCCARTIN: Well, we finally got out of
11 the repository now. We have an ash deposit on the
12 ground, and the question is one of with this ash
13 deposit at the RMEI location, how is it going to
14 evolve with time? There are really processes that
15 could remove material. There's processes that can
16 bring it in from, say, flooding from the repository,
17 100-year flood comes in and washes some of the ash
18 from near the mountain down to the RMEI location.

19 Right now, NRC has a simplified approach.
20 I have "conservative" with a question mark. I think
21 the gut reaction is that this is a conservative
22 approach. However, having criticized DOE for doing
23 the same thing, what is your basis for saying it's
24 conservative? And I think we have to do more work to
25 understand that. It may very well be.

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1 Right now, we're having the ash plume blow
2 in the direction of the critical --

3 MR. LEVENSON: Excuse me a minute, Tim.
4 Before you get to the ash moving, what was the
5 approach in deciding what the composition of the ash
6 was, the ratio of plutonium or fission products or what
7 have you, to ash. Is this concentration of mass
8 involved here?

9 MR. McCARTIN: Well, there's the volume of
10 the mass of the --

11 MR. LEVENSON: You've got a limited number
12 of containers that have failed, and a huge amount of
13 ash.

14 MR. McCARTIN: We're assuming a uniform
15 mixing. At the RMEI location, the material that's put
16 down is uniform within the ash.

17 MR. LEVENSON: And the difference in
18 density of a factor of 10 doesn't give you any
19 segregation at all.

20 MR. McCARTIN: Right now, we're not
21 accounting for those kinds of things.

22 MR. HILL: Please recall that it's being
23 incorporated into molten material, not adhering on a
24 solid.

25 MR. CODELL: This is Dick Codell, NRC. We

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1 are working on an alternative model of the fuel ash
2 incorporation where we do take density into account,
3 and it may supersede the incorporation ratio model.
4 In this case, the fact that the fuel is much denser
5 than the ash could lead to more small dense particles,
6 which may behave differently once they are thrust out
7 into the atmosphere, although we don't really have an
8 adequate model for dealing with that atmospheric
9 transport.

10 MR. HILL: We did do a very quick scope
11 that even if we fail 10 waste packages, there still --
12 with a small volume tetra eruption, you're dealing
13 with .01 weight percent of high level waste in the
14 total amount of the eruption. So this is really a
15 trace component in the total mass core volume of the
16 eruption.

17 MR. LARSON: But it would seem reasonable
18 that you could get some stratification in terms of the
19 distribution of the fuel contained tetra. It just
20 seems logical that there would be a stratification
21 with the density --

22 MR. LEVENSON: Especially at the low flow
23 rates. At the relatively low flow rates, there's not
24 turbulent mixing as this goes down the drift.

25 MR. CODELL: Well, the true is, what's

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1 likely to happen, though, is that the biggest ash
2 particles will take the biggest fuel particles with
3 them, simply because there's more of the bigger ash
4 particles. There's more mass in the bigger ash
5 particles, so it's not going to change density of the
6 mixture that much. My best guess is it's a relatively
7 small effect.

8 MR. LARSON: But calculations are being
9 made on this?

10 MR. CODELL: Yes.

11 MR. LEVENSON: Having spent a number of
12 years trying to mix things to get uniformity, and
13 knowing how difficult it is, I have trouble assuming
14 this kind of a thing. I mean, the flow down the tubes
15 is not fast enough to push the containers, and yet
16 you're assuming complete mixing of everything which is
17 coming long after the containers have failed. It
18 doesn't sound like a good assumption to me.

19 MR. HILL: Just to follow up with that,
20 we're considering that we're dealing with a very
21 complex gas-fluid mixture that's taking a very
22 irregular geometry. Even though we talk about
23 horizontal flow, it's coming up from depth vertically
24 as about 50 percent fragmented -- 50 percent gas
25 volume, 50 percent magma -- both horizontally and then

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1 breaks and goes vertically again along something that
2 starts off as a 5 meter in diameter tube, but we have
3 every reason to believe that as the wall rock is
4 stressed, the over- and underpressure will be plucked
5 and scoured the way any other volcanic conduit is.

6 So, while we may develop a quasi-angular
7 flow regime, there's going to be backpressure within
8 the system and there's going to be angular collapse if
9 it has any reasonable analogy to a volcanic conduit.
10 Both will produce an incredible amount of churning and
11 turbulence within the deposit. So, it may not be
12 uniformly turbulent with continuous incorporation, but
13 for the duration of the eruption, something on the
14 order of three weeks, we'd be having repeated overturn
15 and convection within the system. It would be hard to
16 say that you would keep segregation throughout the
17 duration of an eruption.

18 CHAIRMAN GARRICK: Does the scouring and
19 the other phenomena that's taking place have a
20 significant effect on the density?

21 MR. HILL: There may be very transient
22 effects due to gas resorption during slight
23 overpressuring, but that would quickly be -- it would
24 only be in the change in the bulk.

25 MR. LEVENSON: Because the wall is almost

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1 the same density as the magma. It's the fuel that's
2 a factor of 10.

3 MR. McCARTIN: In addition to having the
4 wind blow south to the RMEI location, the question is
5 how long does that deposit persist at the RMEI
6 location? And right now we have a half-life of
7 approximately 1,000 years for the persistence of that
8 deposit. That's primarily based on the fact that in
9 looking at analogous deposits, that they seem to
10 persist in an area for around 10,000 years.

11 CHAIRMAN GARRICK: What do the wind rows
12 look like at Yucca Mountain?

13 MR. McCARTIN: It's quite varied, and it's
14 approximately, I'll say, on the order of 30 percent of
15 the time due south. Now, the other part of this is
16 that we don't account for any movement in to the
17 dislocation from other parts, to the flooding, et
18 cetera. There's no remobilization. We are merely
19 subtracting. It is a simple approach. Like I said,
20 we're actually going to try and do a fair amount of
21 work this year to get a better sense of the
22 reasonableness of this approach.

23 DOE has partly a similar approach. They
24 are having the wind blow due south also, however, in
25 terms of how long does the deposit persist, I estimate

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1 a half-life of around 50 years, so it doesn't persist
2 nearly as long. And I'm trying to understand a little
3 better -- they do not use the half-life concept, they
4 have a different kind of approach, but between the
5 erosion rates they use how thick the ash deposits are,
6 I'm estimating that -- I think I'm close, but I may be
7 off on that -- but you can see significantly different
8 half-life than the NRC. At the NRC, we're looking for
9 a much longer lived.

10 CHAIRMAN GARRICK: As I recall, you used
11 the same erosion rate for longer periods of time as
12 you did for initial periods, did you not?

13 MR. McCARTIN: Yes. I mean, it's a
14 constant.

15 (Slide)

16 In terms of what this might mean, I think
17 in terms of the redistribution, I think increasing the
18 removal rate, if we went to a shorter half-life for
19 the deposit, I think there could be possibly an order
20 of magnitude difference. I'm not convinced of that,
21 but it could be between the DOE and the NRC approach.

22 There are a lot of other effects that need
23 to be considered in that. In terms of path forward,
24 I think next year we're going to try to evaluate, if
25 we take into account the local wind effects. As you

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1 were saying -- Brit was indicating this could be last
2 three weeks, a month. How does this deposition look
3 like with a varied wind pattern? I think it would be
4 useful to look at that. Knowing, of course, what you
5 get in one area, you take away. Then if you spread it
6 out more, you have to be a little more careful about
7 the redistribution over time. And that's why we want
8 to understand, I think, better -- the risk
9 significance this year is, how much does this
10 redistribution really matter, and do some, obviously,
11 sets giving analyses with the TPA code and see exactly
12 what some of those assumptions mean. There's a lot of
13 -- one of the key things you want to be very careful
14 with in any analysis, and especially the TPA code
15 where there is a host of interconnecting things,
16 getting much better on one aspect like, say, the wind,
17 and neglecting these other things, the confounding
18 sensitivities that you might create by getting very
19 sophisticated in one area and not doing it in another
20 area, and that's a very complex problem that's part of
21 this analysis. Certainly, I can get better in one
22 area, but in terms of the overall analysis, what have
23 you now done.

24 CHAIRMAN GARRICK: Sometimes this is
25 referred to as the "lamppost" syndrome.

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1 MR. McCARTIN: Absolutely, yes.

2 MR. LARSON: At what depth do you no
3 longer consider the radioactivity? You get an
4 accumulation. What is the maximum depth of
5 consideration?

6 MR. McCARTIN: Well, we only look at the
7 top 3 millimeters in terms of what would be possible
8 to be in the mass load, in the particulates. Now, we
9 keep track of the entire blanket in terms of -- or
10 deposit for how long it persists there, but in terms
11 of what's available for an inhalable dose, it is, I
12 believe, is the top 3 millimeters. It's some small
13 amount.

14 MR. LARSON: Taking into account the
15 porosity of the tetra amount?

16 MR. McCARTIN: Yes. Now, DOE has a
17 slightly different approach. They assume all the
18 radionuclides are in the top centimeter. We do not do
19 such a thing. That's where we start comparing that
20 very carefully. We're looking at the -- it's an
21 average -- it's uniformly mixed through the entire
22 deposit. DOE takes the radionuclides, as far as I
23 understand it, and puts them all in the top
24 centimeter. So, there are differences. There's a lot
25 of subtle differences. I tried to get on the ones

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1 that -- for now, we'll be doing some analyses in the
2 future.

3 Here's another area where we think we can
4 improve the understanding of erosion processes and
5 things. Certainly, some surface water hydrologists at
6 the NRC -- Ted Johnson has been out to Yucca Mountain
7 to help us better understand how things might change
8 with major floods, et cetera. And so we're hoping to
9 do some more work along that line. And certainly with
10 respect to redistribution, there certainly are analogs
11 for movement of even ash deposits. I know Brit and
12 some of this Center colleagues have been to Sierra
13 Negro where there's an ash deposit, et cetera. So
14 there is some information that hopefully we can
15 continue to --

16 MR. LEVENSON: Tim, before you leave that,
17 remobilization, in this same infamous report, it says
18 "The high level waste contaminated tetra fall deposit
19 will be modified by wind and water for many years
20 after the eruption can be transported away into the
21 critical group by wind and water following most future
22 eruptions". Are you analyzing multiple eruptions?

23 MR. McCARTIN: No. Once again, I'd have
24 to read the whole page. I recognize the one sentence.
25 We certainly only analyze a single event. I don't

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1 know -- Brit, do you know?

2 MR. HILL: I was the author of the report,
3 I think I can clarify that. You consider a variable
4 wind rows for any future eruption most of the time,
5 unless you had a wind directed blowing towards the
6 northwest sector at an extremely high wind speed,
7 something on order of 10s of meters per second, you
8 would have an appreciable amount of tetra falling on
9 east-facing slopes that drain into the 40-mile wash
10 drainage system. So, for most eruption scenarios, you
11 would have, even if the plume is directed away from,
12 at that time, the critical group location, you would
13 still have tetra that would fall on slopes that would
14 feed into 40-mile wash and the potential grade leading
15 down to the critical group location. It's very
16 difficult to have an eruption for a probability at the
17 proposed repository site, and not have material
18 eventually end up in 40-mile wash, even if the plume
19 is 180 degrees from it.

20 MR. LEVENSON: Well, that I understand,
21 but that's not what this says. This talks about
22 future eruptions many years later.

23 (Simultaneous discussion.)

24 MR. HILL: I know we haven't appreciated -

25 -

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1 MR. LEVENSON: Maybe it's just the words
2 that are here. I'm just reading what's here.

3 MR. LARSON: Is DOE conducting similar
4 studies?

5 MR. McCARTIN: Certainly, they have
6 evaluated the redistribution and the erosion at the
7 location of the RMEI. They right now are -- I don't
8 know in terms of analogs off the top of my head, I
9 know they are using USDA numbers for similar kind of
10 areas to get a general erosion rate.

11 MR. LARSON: There was some talk about
12 using Sunset Crater at one point.

13 (Simultaneous discussion.)

14 MR. McCARTIN: Could be, I'm not familiar.
15 But it is an aspect of the calculation that certainly
16 we think has some importance.

17 (Slide)

18 Finally, you end up getting a dose, and
19 the inhalation scenario generally is related to how
20 much dust or ash mass is in the air. Estimating the
21 mass loading as uncertainties, there are assumptions
22 about outdoor activities, et cetera.

23 For the NRC approach, once again, we have
24 -- and I tried to put these in similar terms between
25 ourselves and DOE for ease of comparison. We don't

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1 use an average over 10 years, but DOE's numbers were
2 presented in that way, and so it's slightly easier.

3 As you can see, we have approximately on
4 average about 1.5 to 2mg per cubic meter. How did we
5 get that number? There are three components to it.
6 The first one is a high disturbance, and that's
7 looking at activity such as farming and plowing where
8 a lot of dust is raised, possibly traffic on roads, et
9 cetera, and there's a certain exposure time to that.
10 We have approximately 1 percent of the time in this
11 high disturbance type of activity.

12 Next, a lower value of mass loading for
13 general outdoor activity, being outside, walking,
14 other types of things. That exposure time is around
15 20 percent, and then sort of a background level that
16 is at around -- add the two, it will be around 79
17 percent to get to the 100 percent.

18 Generally, the dose is dominated by the
19 first two. Those two contributing about the same. You
20 can see right now you have about an order of magnitude
21 higher mass loading for this value, but the exposure
22 time is about an order of magnitude less. So, between
23 the two, the overall dose is really dominated by those
24 two.

25 In terms of, well, how long does it stay

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1 dusty? What we do, we have a background mass loading
2 that is significantly smaller, and we have a half-life
3 of 10 years, and so this higher mass loading decays
4 into the background with a half-life of about 70
5 years. So, at approximately 70 years, it's going to be
6 pretty much at that background, but it gradually
7 decays. And that is an assumption. Some of that is
8 based on analog information at Sera Negro. That
9 deposit has been there for a while. How long will
10 this ash stay there in a fairly --

11 CHAIRMAN GARRICK: So what are some of
12 these conditional dose rates?

13 MR. McCARTIN: It depends on when -- well,
14 it's dependent on many things. Probably the two
15 biggest variables to give you would be -- one would be
16 the time that the dose occurs, primarily because of
17 decay of some of the key -- the short lived nuclides
18 that you don't see in the groundwater pathway, but if
19 you have an event at, say, year 100, it's certainly
20 more prevalent there rather than at 500 years.

21 And then how many waste packages do you
22 assume are entrained -- and it's always dangerous to
23 go off the top of your head, however, I will try to
24 give you my best estimate. I believe that for our
25 base case, it's on the order of 10-to-100 rems at 100

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1 meters. So that would be the worst event, and that's
2 using these assumptions and everything else.

3 MR. HILL: This is in the IRSR Rev 2, and
4 Tim is correct, at about 100 years it's on order of an
5 average of 100 rems. At 1,000 years, it's on average
6 of order 10 rems, and by 10,000 years it's on average
7 of 1 rem as the conditional dose in that given year.
8 But it is in IRSR Rev 2.

9 CHAIRMAN GARRICK: Of course, if you were
10 talking about a 100-year compliance period, you'd be
11 talking about a substantially different probability.
12 So, the weighted risk is still the way you have to
13 look at it. But I was curious. Thank you. I wanted
14 to know what those numbers were.

15 MR. McCARTIN: There's been a lot of
16 evolution of this calculation, and even in the IRSR
17 Rev 2, we have changed -- some of the mass loadings
18 have reduced since then, and so there's a lot of
19 thinking going on, but certainly we're in the right
20 ballpark.

21 MR. HILL: I don't think we've had order
22 of magnitude changes, but again an order of --

23 CHAIRMAN GARRICK: Well, I think the way
24 you've stated it in terms of mg/m³ is the way to start
25 this process.

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1 MR. LEVENSON: Do you have an estimate for
2 how much solid material is deposited in the lungs if
3 you're breathing 4.5 to 9 mg/m³? Do you die of the
4 dirt in your lungs?

5 MR. MCCARTIN: No, no, it's not that high.
6 And be aware -- and this is another aspect that we're
7 looking at with respect to -- I mean, it's -- and be
8 aware that that's for 1 percent of the year at that
9 high number, so --

10 MR. LEVENSON: No, no, I was looking at
11 the 4.5 to 9, which is 20 percent.

12 MR. HILL: That's total suspended
13 particulate, so an appreciable portion of that doesn't
14 go into the lungs.

15 MR. MCCARTIN: That's what I was trying to
16 get to, is the -- one of the things we want to look at
17 -- I know DOE accounts for a much lower value than we
18 would for what gets ingested, but some of this is
19 larger particles that get into the nose and ultimately
20 get ingested.

21 My understanding, in talking to our health
22 physicist, is that doesn't cause -- it still causes a
23 fairly significant dose, not as low as the DOE is
24 estimating. I'm not sure why those differences are
25 there, that's another aspect that we want to look at.

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1 I don't know who has the more reasonable approach, but
2 we're looking at -- in my mind, I thought -- we looked
3 at particles that were inhaled through the nose and
4 ultimately ingested, not going into the deep lung,
5 caused about a factor of 2 lower dose than what was
6 inhaled into the lung. And so it isn't quite as
7 important.

8 For DOE, I thought I remember reading
9 something that was 3 orders of magnitude less, and I'm
10 not quite sure why that difference is there, and
11 that's something that I want to --

12 MR. LEVENSON: Well, that would be a big
13 function of time because if you are a couple of
14 thousand years down the road and most of what's left
15 is plutonium, it pretty much goes through your gut,
16 it's not absorbed at all, whereas in your lung you get
17 the dose. So that ratio would be a big swing with
18 time.

19 MR. McCARTIN: Yeah, and that's -- once
20 again, it's another thing we're looking at, but in
21 terms of deep ingestion into the lung, we're not
22 looking at. It's not causing a significant health
23 problem just because of the dust itself.

24 CHAIRMAN GARRICK: Well, thanks to us,
25 we've extended this a little, so maybe we'd better try

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1 to wrap up this before we freeze to death.

2 Who controls the thermostat in this room?

3 Is there a reason that door is open?

4 VOICE: Yes, sir.

5 MR. LARSON: To let the heat in.

6 CHAIRMAN GARRICK: Oh, to let the heat in.

7 Oh, okay.

8 MR. BAHADUR: It is by design so that the
9 meeting will be really short.

10 (Laughter.)

11 CHAIRMAN GARRICK: It didn't work. Okay,
12 Tim.

13 MR. MCCARTIN: I will try to go quickly.
14 The DOE approach is -- we're not that different, but
15 you can see we got to these numbers quite a big
16 differently. DOE has an outdoor value that they have
17 32 to 45 percent of the time, and an indoor value for
18 the remainder. However, they have a mass loading that
19 applies for 10 years. After 10 years, they're at the
20 background level, and so it drops off quite a bit
21 quicker than ours.

22 (Slide)

23 In terms of the risk insight, if I look at
24 the differences between our two approaches and be
25 aware that there still is a fairly fluid situation, in

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1 my mind, because of the different approaches, also the
2 part that DOE puts all the radionuclides in the top
3 centimeter, there's a lot of little things there. But
4 I think, I'll say around a factor of 5 difference in
5 risk.

6 What are we going to do? we're going to
7 start -- continue to look at analog systems for what
8 is the right mass loading for different situations.
9 As I mentioned, Brit, they've done some measurements
10 at Sera Negro that can be used.

11 What's the evolution of the ash particle
12 over time? As was indicated, once you get up in the
13 air is a big part of this calculation, when this ash
14 is deposited. How much of this and how does it change
15 the particle size, that also is an important part.
16 See, there's a lot of subtleties here that need to be
17 considered.

18 And the last one that we're looking at is
19 there has to be a correlation for how long the deposit
20 persists and how dusty it is, and there certainly
21 should be some -- if there's a lot of it in the air,
22 the wind is blowing, it shouldn't last very long, and
23 we'll be looking at that aspect of it for
24 reasonableness, how long the deposit continues, and
25 that's where the remobilization and the inhalation --

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1 this is one where there's just a lot of
2 interconnection between what assumptions are being
3 made.

4 And the next two slides is really -- and
5 I'll try to go through them very quickly, and I think
6 I can --

7 CHAIRMAN GARRICK: They are very good, and
8 they are quite self-explanatory.

9 (Slide)

10 MR. McCARTIN: Right. And what this --
11 this is sort of a preview for the future, and what
12 we're trying to work on is a simple explanation of the
13 approaches in the TPA code, where the uncertainties,
14 how we got to where we are. I think we would like to
15 do this for both our own code, but also for the DOEs,
16 possibly a way to provide a very simple, quick way of
17 explaining, understanding of the Repository. And
18 rather than going through the igneous slide, which
19 really is in some areas pretty much a summary of what
20 you just heard, I will skip past that and go --

21 (Slide)

22 -- one of the things we're hoping to learn
23 from this exercise is that, indeed, as Marty
24 indicated, we're treating uncertainty in a similar
25 fashion. That may not be the case everywhere, but I

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1 think it is important to understand how we're dealing
2 with uncertainty. And this may be -- I said earlier,
3 when we're a little further along with this for the
4 entire TPA code, it may be useful to come back to the
5 committee and go through this and get feedback.
6 There's a lot of different areas of the TPA code.

7 For example, what really matters for waste
8 package? Well, if you have a waste package that you
9 think is going to last past 10,000 years, initial
10 defective packages are quite important. the question
11 is, the uncertainty in estimating that is the
12 manufacturing process, the closure, weld defects, are
13 things you have to consider. Right now, in the TPA
14 code we have -- we're going from 0.01 percent to a 1
15 percent failure based primarily looking at some analog
16 manufacturing information.

17 CHAIRMAN GARRICK: Boy, that's a big jump.

18 MR. McCARTIN: Yes. Well, on average,
19 0.01 percent.

20 In terms of the corrosion, as we
21 indicated, what are the big uncertainties there, and
22 certainly the hydro-chemical/thermal environment is
23 the key there, and certainly we have the short-term
24 measurements, and the effect of the welding, and the
25 post-welding, et cetera, what's the going to do to the

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1 lifetime.

2 Our current approach is that the corrosion
3 rate is based on the relative humidity, however, how
4 do we account for more aggressive water chemistries?
5 We have a chloride multiplication factor that
6 increases the chloride content and thereby affects the
7 waste package failure time. Right now, failures, as
8 indicated here for uniform passive corrosion, it's on
9 the order of 10,000 to 45,000 years.

10 Dripping on the waste package. Where will
11 packages get wet? You have possibilities in the
12 hydrologic environment for focusing flow. You also
13 have diversion, capillary diversion of water. And so
14 you've got a couple of processes there. In terms of
15 the fraction of waste packages that get wet, we have
16 a very broad range there. It's all of them or none of
17 them. We sample between the two. There is a lot of
18 uncertainty there, and you can see we've taken the
19 full range.

20 However, within that, there is -- I'll
21 maintain it's Dick Codell's finest moment at NRC. He
22 may not think so, but in terms of how do you try to
23 represent this dripping aspect, and he came up with
24 some factors that account for how much water is
25 dripping onto the waste package, and it's correlated.

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1 Although we do sample between zero and 1, when you get
2 close to 1 where all the packages are being dripped
3 on, it's a little bit of water. Clearly, you have
4 drips everywhere. You have a finite amount of
5 infiltration. The amount of water than can drip on a
6 package is small.

7 On the other end of the spectrum, when you
8 get to very few waste packages, you have some focusing
9 of flow, so you get a lot of potential for more water
10 dripping on the containers because you have very few
11 getting wet, but obviously where it's flowing there
12 has to be more water to account for -- and I'll turn
13 to Bill's infamous conservation of mass. We've got to
14 account for the water. You can't have a lot of water
15 on a lot of packages. It's a lot of water on a few
16 packages or a little bit of water on a lot of
17 packages, and that really is what that tries to
18 account for.

19 Right now, how does that vary? We go from
20 basically 1 percent of the infiltration rate when a
21 lot of them are getting wet, to 3 times when very few
22 packages get wet. So, you can see the range of the --

23 MR. LEVENSON: Three times as much water
24 reaches the package and comes in?

25 MR. MCCARTIN: No, 3 times the

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1 infiltration rate.

2 MR. LEVENSON: It would be more than
3 filtration rate.

4 MR. McCARTIN: Not in volume, it's focus.

5 MR. LEVENSON: Oh.

6 MR. McCARTIN: The infiltration rate is --

7 CHAIRMAN GARRICK: Funneled.

8 MR. McCARTIN: Right. In terms of the
9 drip shield, right now in our code, we have no
10 mechanistic model for its failure. We specify a
11 failure of time, which is approximately 5,000 years.

12 CHAIRMAN GARRICK: That's quite a bit
13 shorter than TSPA/SR at least.

14 MR. McCARTIN: Yeah, I think so.

15 CHAIRMAN GARRICK: It was about 20,000
16 years, as I recall.

17 MR. McCARTIN: But you can see, for us --
18 once again, getting back to what causes corrosion,
19 it's the humidity. So, whether we have drips or not
20 really doesn't affect the corrosion rate as much, but
21 in terms of can spent fuel, if there is an initial
22 defect, can water get in to mobilize the waste, the
23 answer would be no. And as I indicated, we do not
24 have a diffusive release, we only have an invective
25 release, so you do have to have dripping water. We

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1 sort of felt without dripping water, you weren't going
2 to get anything out of the waste package. DOE would
3 have releases from drips.

4 CHAIRMAN GARRICK: So the drip shield
5 serves your model.

6 MR. McCARTIN: Yes.

7 CHAIRMAN GARRICK: And essentially does
8 not serve the DOE model.

9 MR. McCARTIN: No. I mean, if they had a
10 defective canister underneath the drip shield, even if
11 the drip shield was intact, the way I understand it,
12 they would still have releases.

13 CHAIRMAN GARRICK: Well, they are based on
14 diffusivity transport.

15 MR. McCARTIN: Yes. Spent fuel cladding,
16 as I indicated, right now there is the unzipping of
17 the clad. We think it's fairly uncertain what kind of
18 zipping would occur over hundreds of years, and just
19 thermally you're not going to see dripping for quite
20 a while, so you're looking at this not really as put
21 into the repository, but quite a few hundred years
22 afterwards. We right now take no credit for --

23 CHAIRMAN GARRICK: And that's kind of
24 evidence supported. There are thousands of assembly
25 years of experience with no such phenomena observed.

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1 MR. McCARTIN: And then the final one is
2 diffusion of the radionuclides from the waste package.
3 There clearly is a very complex chemistry inside the
4 waste package, however, when we've done our analyses,
5 when you have dripping into the waste package, the
6 invection will dominate.

7 We have not included diffusion when -- you
8 get a hole and all of a sudden things start diffusing
9 out. we just don't include that, but we're aware of
10 it. We may do some additional analyses along these
11 lines because of the DOE model. At one time, be aware
12 that we did have it in our TPA code. We removed it.
13 It cost a lot of computer time and produced such a
14 small release, we said why bother. We may add it back
15 in, and we'll look at it, but --

16 CHAIRMAN GARRICK: This was the bathtub
17 model.

18 MR. McCARTIN: No. I mean -- well, we saw
19 the bathtub model, but a diffusional release out of
20 the waste package at one time we had. We removed it.
21 We were thinking about putting it back in due to the
22 DOE model, but I think the important thing is we
23 recognize the differences. DOE appropriately shows us
24 what the diffusional release is, the invection
25 release, so we can understand the differences, but

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1 it's an interesting aspect between the two.

2 With that, like I said, we hope to do that
3 for all the codes, and this was really a very quick
4 cut. We've just begun it. We hope to improve the
5 detail and information on there.

6 (Slide)

7 With that, let me wrap up very quickly.
8 What we're trying to do is improve our understanding
9 in areas important to representing the consequences
10 from magmatic events and --

11 MR. LARSON: Time, as a result of that
12 improved understanding, have you come up with any FEPS
13 that the DOE has disregarded that should not be
14 disregarded? Is this being looked at?

15 MR. McCARTIN: Well, we certainly look at
16 the FEPs. In a general sense, I'd say no. They
17 certainly are looking at the alternative flow paths as
18 another -- although, there's a part -- is that a
19 different FEP, or is it part of igneous activity?

20 And I'm really not aware of any
21 significant FEPS that we've seen. And how things will
22 change, if I had to give my gut reaction as we go
23 through all this work, I think it's possible one could
24 see a 1 to 2 order of magnitude change. Time will
25 tell. Like I said, there's a fair amount of work we

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1 hope to accomplish this year.

2 I'll make the offer -- none of my
3 management are here, so I can speak freely. I think
4 it would be fair, as this work improves, we can come
5 back and report on this, and certainly I think Brit
6 and John Trapp, as the aeromag data comes in, that
7 clearly mobility is not my strength by any means in
8 terms of how those might change. It might make sense
9 when that is, as that's analyzed, to come back also.

10 CHAIRMAN GARRICK: A couple of closing
11 questions. How many agreements are outstanding on
12 this KTI?

13 MR. HILL: We had 22 to begin with. I
14 believe 6 are completed -- 7 are completed -- close
15 enough.

16 CHAIRMAN GARRICK: If all of this goes in
17 the wrong direction, are we heading in a direction
18 that could make this a possible problem?

19 MR. McCARTIN: Well, I guess my impression
20 of the estimates are I find it very hard to believe
21 that these things at all go in one direction. I think
22 that is a very -- although there's no guarantees in
23 life, but I think it would be very, very odd that they
24 would all go in one direction or the other. And so my
25 personal take is that I think we're probably closer to

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1 maybe it stays the same and maybe it drops an order of
2 magnitude.

3 MR. LARSON: So your estimate there is not
4 net, but individual estimates?

5 MR. McCARTIN: No, it's net. If I had to
6 be pinned down, and that's what this is trying to do,
7 I'd say 1 to 2 orders of magnitude, and I think that's
8 the net change. Which direction is it? I think most
9 likely it's the lower, my gut reaction at this time.
10 There are things that could make it higher. You saw
11 a combination of both. Probability could increase.
12 Number of waste packages might increase. I think mass
13 loading probably will be reduced. So, where you end
14 up I don't quite know.

15 CHAIRMAN GARRICK: Andy, are they wanting
16 anything from us on this, or is this informational?

17 MR. CAMPBELL: Well, this is primarily
18 informational preparation for future ACW reports to
19 the Commission, but if the committee feels that it
20 would like to weigh in on this issue, this is probably
21 the time to do that because this is a particular KTI
22 that's been talked about.

23 MR. LEVENSON: Can I ask one more question
24 out of ignorance, which is where most of mine come
25 from. Why is Mount St. Helen's not referred to as

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1 anything that might be an analog, is it so different?
2 Probably better measurements on that than most.

3 MR. McCARTIN: Well, in terms of -- Brit
4 probably can answer this better than I, but I'll put
5 my two cents in first and then go to Brit.

6 I do know DOE, in their reports, they
7 certainly cite Mount St. Helen's as the basis for
8 their ten-year -- after ten years reducing the mass
9 loading to the background. And so they are looking at
10 some of that information. There are aspects of the
11 eruptiveness that are -- in terms of the mass loading,
12 there are some limitations of Mount St. Helen's.

13 If you go near there in terms of --
14 there's a lot of education, different soil types than
15 Yucca Mountain, et cetera, that you have to take into
16 account when you look at if the ash can be easily
17 incorporated into the soil there versus possibly at
18 Yucca Mountain soils, and that's something that has to
19 be considered. But I think we try to look at
20 everything that's analogous, and I'll ask Brit if he
21 has some other thoughts.

22 MR. HILL: Just a couple of very quick,
23 off-the-top points. First, the grain size character
24 of the Mount St. Helen ash, especially in the areas
25 where the occupational studies were done for particle

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1 concentration. It's fundamentally very different from
2 what we see from basaltic ash.

3 Second, it is highly dedicated, well
4 established soil that receives a lot more rainfall
5 than we see from the Yucca Mountain sorts of
6 scenarios. So the granulometry is different, the
7 depositional area is different. The volume away from
8 about the initial deposit itself is fairly small and
9 very thin deposits. On slopes and terrain it really
10 was very stable to begin with, and also very permeable
11 to begin with, that allow a lot of infiltration to
12 occur.

13 So, while we can gain some general
14 insights from the Mount St. Helen's information,
15 trying to understand what's happening between zero and
16 20 kilometers away from the Yucca Mountain system has
17 some fairly significant limitations.

18 MR. LEVENSON: We're assuming no climate
19 changes for these 10,000 years, right?

20 MR. HILL: We're looking, though, at these
21 peak risks from volcanic disruption occurring on the
22 order of the first thousand years. So, while climate
23 change would affect the 10,000 year view for the
24 period that we're most concerned about, we're not too
25 worried about climate change. There's at least no

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1 evidence to support significant climate change in the
2 first thousand years.

3 MR. LEVENSON: And that affects the
4 probability by a factor of 10.

5 MR. HILL: The probability is the same at
6 any given year. There's really no -- with the
7 homogenous fall recurring rate, there's no effective
8 difference between the probability in year 100 and the
9 probability in year 10,000.

10 MR. McCARTIN: When we do our
11 calculations, we're looking at year one, the
12 probability. We're not, say, taking the event,
13 multiplying by 10,000 years, and getting a single
14 probability to then say -- and I don't know, maybe Dr.
15 -- this may not be as clear. We don't say take 10^{-7}
16 times 10,000 so the probability of that event --

17 CHAIRMAN GARRICK: No, I understand.

18 MR. McCARTIN: -- okay -- at year one,
19 it's 10^{-7} .

20 CHAIRMAN GARRICK: Right. Okay. Any
21 other questions from any of the members, consultants,
22 staff? Yes?

23 MR. HAMDAN: Tim, just one question. I'm
24 not clear on the one aspect of this. Are we saying
25 that every igneous activity will have an intrusive

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1 component and risk, and extrusive also?

2 MR. McCARTIN: Yes.

3 MR. HAMDAN: So, how are you deciding how
4 much of the event is extrusive and how much is
5 intrusive? Do you assign probabilities, or how do you
6 go about doing that?

7 MR. McCARTIN: For us, right now, we
8 merely -- we have -- we specified a number of waste
9 packages that will be affected by intrusion. We have
10 not worried that much about assigning a specific
11 probability, we just -- we can allow it to occur at
12 the same time we do the eruptive one, but it tends to
13 be -- relative to the eruptive one, it's a very small
14 risk value.

15 MR. HAMDAN: So, how about an intrusive
16 event -- how about an igneous activity when that does
17 not include eruption?

18 MR. McCARTIN: It could be a factor of 10
19 or higher in terms of probability.

20 MR. HAMDAN: Is that modeled --

21 MR. McCARTIN: We can. I mean, right now
22 the intrusive event is for us a very small amount.
23 DOE obviously has a larger one and, like I said, we'll
24 be looking at those differences. It's quite possible
25 we have it wrong. If it comes up in consequence, then

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1 maybe we need to look at it a little more carefully.
2 But, right now, we see it dominated by the eruptive.

3 CHAIRMAN GARRICK: Andy?

4 MR. CAMPBELL: I was just going to ask if
5 there was anything to be gained in terms of ash
6 distributions from looking at similar type of basaltic
7 cones, signatory cones, in the basin and range. You
8 mentioned Sunset Crater. Is there anything to be
9 gained from studying the volcanoes that are there at
10 Yucca Mountain in Crater Flats? Are they so old that
11 anything that you can interpolate to 10,000 years has
12 long since gone?

13 MR. HILL: Right. The youngest volcano is
14 80,000 years old, and almost all the ash deposit is
15 gone, there's just a fragment here and there. In
16 terms of the basin and range, the Sunset Crater is
17 about 1,000 years old. It's much larger volume. But,
18 again, one of the two volcanoes of similar type that
19 still has a preserved deposit, we're not using it as
20 a direct analogy, we're trying to look at how tetra
21 would behave, but not how the eruption would progress.

22 That's why we've been using the historical
23 analogs, because we have nothing in the basin and
24 range that's historical, and most of the deposits are
25 before the highly eroded condition, so we look at much

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1 younger deposits on the order of 50 to erupting while
2 we watch, so that we can better understand the
3 dispersive processes.

4 But looking at places like in Mexico or
5 Sunset Crater and then comparing those to the older
6 volcanoes in the base and range, that's where we came
7 up with the scaling for at 1,000 years there seems to
8 be some deposit left, at 10,000 years it seems to be
9 pretty well gone. So, the 1,000 year half-life that
10 we're using is really a scale of 100 year, 1,000 year,
11 10,000 years. You see it at 1,000, we don't see it at
12 10-, and clearly it's there at 100. So, 10,000 year
13 it's all gone, given a half-life of 1,000, that seems
14 to be the best first pass.

15 MR. CAMPBELL: One other question for Tim,
16 on these tables that you developed at the end of your
17 presentation, is there any thought to developing a
18 column to identify built-in conservatisms, and this is
19 an issue the committee has been dealing with, and kind
20 of raised it in the context of TSPA/SR of identifying
21 conservatism. Has the staff thought about it, you
22 guys thought about, you know, looking at how
23 conservatisms are being treated and carried through
24 the model? Is that part of all this?

25 MR. McCARTIN: We certainly will look into

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1 that. I'm always trying to think of a better word
2 rather than "conservatism". I don't think there is
3 one, unfortunately. The only reason I say that, we
4 need to get to that, but part of it is the information
5 you have, and some of it is you're making some
6 assumptions and, as Dr. Garrick said, assumption base
7 versus evidence, so often --

8 CHAIRMAN GARRICK: What might be better is
9 a cryptic identification of the relevant evidence.

10 MR. MCCARTIN: Yes. Absolutely.

11 CHAIRMAN GARRICK: Supporting evidence.

12 MR. MCCARTIN: And that is one there that
13 here's what the evidence tells us, and let someone
14 draw their own view of whether it's conservative or
15 not.

16 CHAIRMAN GARRICK: Any other questions
17 from anybody?

18 (No response.)

19 Okay. I want to thank Brit and Tim for a
20 very informative hour presentation that went a couple
21 of hours, and we look forward to following up with all
22 the path forwards that you identify, and we also want
23 to thank our consultant for his significant
24 contribution in this session, and we will now take a
25 recess and when we come back -- this terminates all of

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1 our briefings and discussions of this type.

2 We will now go into our usual letter
3 discussion and letter-writing session, for which we
4 will not need reporting, and until then we will take
5 a 15-minute break.

6 (Whereupon, at 3:40 p.m., the briefing
7 session was concluded.)
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CERTIFICATE

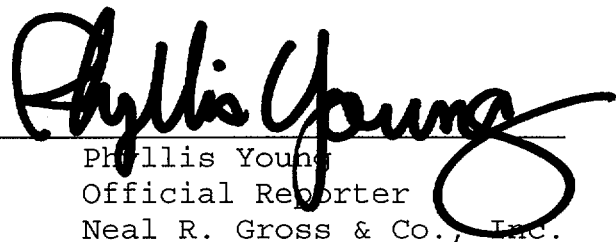
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