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UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION

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ADVISORY COMMITTEE ON NUCLEAR WASTE (ACNW)

146TH MEETING

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WEDNESDAY,

OCTOBER 22, 2003

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ROCKVILLE, MARYLAND

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The meeting convened in Conference Room T-2B3 of the Nuclear Regulatory Commission, 2 White Flint North, 11545 Rockville Pike, Rockville, Maryland, at 8:30 a.m., B. John Garrick, Chairman, presiding.

MEMBERS PRESENT:

B. JOHN GARRICK	Chairman, ACNW
MICHAEL T. RYAN	Vice Chairman, ACNW
GEORGE M. HORNBERGER	ACNW
RUTH F. WEINER	ACNW

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ACNW STAFF PRESENT:

JOHN T. LARKINS	Executive Director, ACRS/ACNW, Designated Federal Official
SHER BAHADUR	Associate Director, ACRS/ACNW
NEIL M. COLEMAN	ACNW
HOWARD J. LARSON	Special Assistant, ACRS/ACNW
MICHAEL LEE	ACNW
RICHARD K. MAJOR	ACNW

ALSO PRESENT:

HANS ARLT	NMSS/DWM/HLWB
ROLAND BENKE	NMSS
TAMARA BLOOMER	NMSS/HLWB
MARK P. BOARD	BSC
JOHN BRADBURG	DWM
ANDY CAMPBELL	NRC/NMSS/DWM/PA
ASADUL H. CHOWDHURY	CNWRA
KEITH COMPTON	NRC/NMSS/DWM/PA
BISWAJIT DASGUPTA	CNWRA
DIANA DIAZ	NRC/NMSS/DWM/PA
NICK DINUNZIO	DOE
DAVID ESH	NMSS/DWM/EPAB
CHRIS GROSSMAN	NMSS/DWM
DOUG GUTE	CNWRA
LAHIF HAMDON	NMSS/DWM

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ALSO PRESENT:

CAROL HANLON	DOE
GREG HATCHEY	NMSS/DWM/HLWB
NORMAN HENDERSON	Bechtel SAIC Company
BANAD JAGANNATH	NMSS/DWM/HLWB
ROBERT K. JOHNSON	NMSS/DWM/EPAB/PA
PHILIP JUSTUS	NMSS/WM/HLW
JOHN KESSLER	EPRI
YONG S. KIM	NRR/DE/EMEB
TIM KOBETZ	NMSS/DWM
PATRICK LAPLANTE	NWTRB
BRET LESLIE	NRC/NMSS/DWM/PA
TIM MCCARTIN	NMSS/DWM
ROD MCCULLEN	NEI
SITAKANTA MOHANTY	CNWRA
MYSORE NATARAJA	NMSS/DWM
GOODLUCK I. OFOEGBU	CNWRA
WES PATRICK	CNWRA
JOHN PECKENPAUGH	NRC/DWM
DAVID PICKETT	CNWRA
JOHN H. PYE	NWTRB
DANIEL ROM	NMSS/DWM/HLWB
JAMES RUBENSTONE	NMSS/DWM
CHRISTOPHER RYDER	NMSS/DWM/EPAB/PA
JIM SHIFFIN	MTS

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ALSO PRESENT:

KING STABLEIN	NMSS/DWM/HLWB
OMID TABATAB	NMSS/DWM/HLWB
E. TIESENHAUSEN	CCCP
GORDON WITTMAYER	CNWRA
MITZI YOUNG	OGC

I-N-D-E-X

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

(8:33 a.m.)

CHAIRMAN GARRICK: Good morning. Our meeting will come to order. This is the second day of the 146th meeting of the Advisory Committee on Nuclear Waste.

My name is John Garrick, Chairman of the ACNW. The other members of the committee present are: Mike Ryan, Vice Chair; George Hornberger; and Ruth Weiner.

Today the committee will hear from the NRC staff on Yucca Mountain preclosure safety and drift degradation issues. We will hear from the staff on the updated staff performance assessment code. We intend to discuss the plan for ACNW review of NRC waste management-related safety research to review our proposed presentation for tomorrow's public meeting with the Commission.

Richard Major is the designated federal official for today's initial session. The meeting is being conducted in accordance with the provisions of the Federal Advisory Committee Act.

We have received no written comments or requests for time to make oral statements from members of the public regarding today's sessions. Should

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1 anyone wish to address the committee, please make your
2 wishes known to one of the committee staff. And it is
3 requested that the speakers use one of the
4 microphones, identify themselves, and speak clearly
5 and loudly, so that we can hear you.

6 Our first topic is going to be the Yucca
7 Mountain preclosure safety and drift-degradation
8 issues. The committee had some briefing on the
9 methodology that's being proposed on this some time
10 ago. In fact, it was a joint subcommittee of the ACRS
11 and ACNW that wrote a report in January of 2002, and
12 that report had three or four comments in it that were
13 of great interest to the committee.

14 One comment had to do with both committees
15 favoring more of a PRA approach than what was at that
16 time described as the integrated safety analysis or
17 safety assessment approach. We also suggested that
18 the ISA, as changes are made in it, that those changes
19 be structured in such a way that it allowed evolution
20 to more of a risk-based approach to safety analysis.

21 The committees -- both committees
22 expressed some concern about the capability of the
23 integrated safety assessment methodology to address
24 dependent events, dependent failures. And we also
25 raised questions about the insights that the ISA would

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1 provide with respect to the aggregated risk, because
2 the version we saw -- there was considerable emphasis
3 on specific scenarios but not on aggregating the risk,
4 so to speak.

5 So we're looking forward to an update. Of
6 course, we're talking about Yucca Mountain
7 applications now. At that time we were just pretty
8 much talking about the methodology itself. I think
9 that the presentation today is something we are
10 extremely anxious to hear.

11 And I understand that Raj Nataraja is
12 going to start off and will introduce all of the other
13 speakers.

14 Raj?

15 MR. NATARAJA: Good morning. Can you hear
16 me?

17 My name is Raj Nataraja, and I am the
18 technical lead for the repository design and thermal
19 mechanical effects key technical issue, which consists
20 of both preclosure and postclosure aspects.

21 And my presentation is going to be quite
22 brief. Basically, I'm going to set the stage for this
23 morning's presentation, which has actually three major
24 presentations but made by four different people.

25 The title for today's -- this morning's

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1 presentation is preclosure safety analysis methodology
2 and drift-degradation evaluation. And what I would
3 like to do this morning is go over the objective and
4 scope of this morning's presentation, talk a little
5 bit about the risk significance of the topics that we
6 have chosen for presentation, and then I will
7 introduce the speakers who are going to make quite
8 detailed presentations.

9 So we are going to cover a lot of ground
10 this morning, and it ranges between the safety aspects
11 that imply -- that are affecting the preclosure period
12 as well as the postclosure period.

13 As I mentioned, the staff has been working
14 on mostly postclosure aspects for quite some time, and
15 have started paying attention to preclosure only in
16 the last couple of years. That was because the work
17 structure was developed in that way, and all of our
18 focus was on the postclosure aspect.

19 However, the first topic that we are going
20 to discuss today is to provide an update on the
21 preclosure safety analysis. We have a tool -- what we
22 call PCSA tool. As you know, the rule requires the
23 Department of Energy to conduct a detailed safety
24 assessment, and the term used there is integrated
25 safety assessment, which basically you have correctly

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1 observed consists of the same steps that the PRA has
2 -- what can go wrong, how likely is it, what are the
3 consequences.

4 And the PCSA tool that we have developed,
5 we have given you a methodology. We'll give you an
6 update today about the application with a specific
7 example.

8 And the second part of the presentation
9 will talk about the long-term effects of drift-
10 degradation, which is a fairly important issue. As a
11 matter of fact, the -- most of the agreements that we
12 have with DOE deal with either the stability during
13 the preclosure or long-term impacts of instability.

14 So the second part of the presentation
15 will focus on how to predict the long-term behavior
16 and its impacts on the design and performance of the
17 engineered barrier system.

18 Just to give some reasons for why we
19 picked up these two topics, as you know, the PCSA is
20 our tool and our methodology that we use to evaluate
21 DOE's design and assess the risk significance of
22 various structure systems and components. And that's
23 how we determine whether the performance objectives
24 are met.

25 And also, DOE will come up with a list of

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1 structure systems and components as part of the safety
2 analysis based on their integrated safety assessment,
3 and we will do some selective review of certain risk
4 significant structure systems and components. And the
5 way in which we determine which will be the focus of
6 a review is based on the work that we do using the
7 PCSA tool.

8 And as far as the drift-degradation issue,
9 there is one technical issue that we have ranked as
10 high, potentially high, in terms of risk under the
11 RDTME KTI. And that is because there is a potential
12 for the impact of the drift-degradation being severe
13 enough to impact a large number of waste packages, if
14 the load is transferred from the rock falling on top
15 of the drip shields. And if the drip shields buckle
16 and transfer the load to the waste package, there is
17 a potential impact on the waste packages.

18 The first presentation on the PCSA will be
19 done by two people. The first part of the
20 presentation, which covers the methodology part, is
21 done by Robert Johnson of the Performance Assessment
22 Branch, NRC staff. And he will be followed by Dr. Bis
23 Dasgupta from the Center. He will go into some
24 details of the application of the two and give a
25 specific example or examples. They may be real or

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1 not, but they show how we use the PCSA tool to
2 evaluate DOE designs.

3 And one important thing that I might add
4 here is that the structure systems and components
5 important to safety as defined will consistent of both
6 an evaluation of the public dose as well as the dose
7 to workers. And it looks like that the dose to public
8 is not a big concern here. Dose to workers is
9 probably the more important and more definite result
10 of the operations. So the two will show examples of
11 how it is applied to both cases.

12 And then, the second part of the
13 presentation will consist of two parts. The first
14 part will be presented by Dr. Goodluck. He will talk
15 about the empirical relationships and some analytical
16 calculations that were used to predict the long-term
17 behavior of an emplacement drift.

18 Actually, this work was initiated as a
19 result of the Department of Energy's assumptions in
20 the SAR performance assessment, which basically made
21 an assumption that an emplacement drift will remain
22 open for 10,000 years. We did not believe there was
23 sufficient technical basis to make such an assumption.

24 So we looked at other possibilities, and
25 a recent report prepared by the Center actually went

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1 into some details and came up with some alternative
2 possibilities. And that's what we will hear in the
3 first part, and the second part will take the output
4 from that analysis and use it as input to the design
5 of the waste package. Actually, we have not come to
6 the waste package part yet. We are looking at the
7 drip shield right now.

8 And we looked at one of the current
9 designs, or at least the designs that we looked at
10 were current at the time when we started this work.
11 And that -- the impact of the rock fall on the drift-
12 degradation and the static and dynamic loads on the
13 drip shield is looked at. And that presentation will
14 be made by Dr. Doug Gute from the Center also.

15 I just have two more slides. I don't want
16 to spend too much time on that. The reason for this
17 is more or less like a backup slide. We haven't
18 talked to some of the new members, so they might not
19 know exactly what the RDTME KTI is all about.

20 It's a mouthful. It takes into account
21 the design and construction of operation --
22 construction and operation of the geologic repository
23 operations area. The word -- if we simply say
24 "repository," you know, discussions, we refer to
25 geologic repository operations area as defined in the

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1 Part 63.

2 And this particular KTI covers both
3 preclosure and postclosure performance objectives, as
4 I mentioned earlier. And we have to worry about the
5 coupled processes and long-term impacts of thermal
6 loading and seismic loading.

7 We have two aspects of seismic loading --
8 the design basis seismic loads that will be used for
9 the preclosure part, and then there are the seismic
10 events that occur during the 10,000-year period, which
11 might impact the long-term behavior of the emplacement
12 drifts and the EBS.

13 And then, the construction and operations
14 sub-issues are also covered under RDTME KTI, but
15 mainly their impacts are during preclosure and the --
16 if they are factored in appropriately for design, then
17 they can be factored appropriately for postclosure
18 performance assessment.

19 We have looked at -- if you have read some
20 of our earlier versions of the IRSRs, you will see
21 that RDTME KTI had four subissues -- design control
22 process, seismic design, thermal mechanical effects,
23 and seals.

24 Actually, design control process was
25 looked at under this KTI simply because we did not

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1 have another place to put it in. We were not actively
2 doing QA at that time. Actually, it belongs under
3 quality assurance.

4 Currently, we have closed that subissue,
5 because the subissue was generated as a result of some
6 of the observations we made during the ESF
7 construction -- design construction and operation.
8 But the same issues might, you know, crop up again
9 when we start thinking about design construction and
10 operation of the repository itself. But apparently
11 that subissue is closed.

12 And the last one -- seals -- is also
13 closed, because that was not relevant to the system
14 that we are in.

15 And most of the agreements that we have
16 which are still being open and looked at are the
17 seismic design and thermal mechanical effects. And
18 there is some duplication here in the sense that this
19 DS and CLST also have lots of common issues and
20 agreements.

21 And, finally, there's a lot of information
22 here which I'm not going to go through, but this is
23 simply to show that we are looking at -- for
24 convenience, we are looking at preclosure.

25 When I said RDTME KTI itself, I already

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1 said that preclosure and postclosure are both part of
2 it. But the reason why we have put preclosure
3 separately here is the KTI structure did not cover the
4 preclosure part.

5 So we are looking at the preclosure
6 aspects under 10 topics, which I believe we made a
7 detailed presentation to you. I think it was at the
8 127th ACNW meeting. We told you what the 10 topics
9 were, and what are some of the issues under each one
10 of those.

11 As you can see, we have right now based on
12 the interactions with DOE we have nine agreements
13 there, two agreements on the identification of hazards
14 and initiating events, which is part of PCSA, and two
15 on identification of structure systems and components,
16 which is also the result of PCSA, and five agreements
17 on the design of structure systems and components.

18 But there are a number of preclosure
19 topics we haven't really touched on yet, so we will
20 probably have more issues that come up later.

21 And under the RDTME KTI itself, as I
22 mentioned, the subissues one and four are closed. And
23 we have a total of 23 agreements currently we are
24 looking at. And as you can see, many of these
25 agreements deal with the stability of underground

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1 openings as it impacts the preclosure operations as
2 well as the impacts on the postclosure performance
3 because of the potential impacts of instability of the
4 emplacement drifts.

5 So, in summary, we chose two topics which
6 we thought were risk significant, one for preclosure
7 and one for postclosure. And we will make some
8 detailed discussions on all of those topics. If you
9 have any quick preliminary questions, I'll be happy to
10 answer. Otherwise, we can move on to the first
11 presentation.

12 CHAIRMAN GARRICK: Any questions at this
13 point? Would you comment on the impact that the
14 absence of a detailed design has had on any of these
15 analyses?

16 MR. NATARAJA: Well, that's been one of
17 our problems all along. And the nature of the
18 repository investigation itself has been one of
19 iterative -- it has to be iterative out of necessity,
20 because they will not know all of the information in
21 advance. So they did the site characterization to the
22 extent they could, and then the more information comes
23 in they keep making revisions.

24 And we have had some difficulties, yes,
25 because we cannot pinpoint any defect in an unknown

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1 design. We can only work on a generic concept. So
2 far we have not seen a final design. But I think it
3 has matured enough for us to raise a number of
4 questions.

5 CHAIRMAN GARRICK: But has the absence of
6 a detailed design maybe made you go in a more
7 conservative direction than you might if you had?

8 MR. NATARAJA: I don't know whether it
9 would be more conservative, but we would like to look
10 at too many possibilities. And some of those
11 possibilities and alternatives might not be realistic
12 simply because we cannot just eliminate it at this
13 stage.

14 CHAIRMAN GARRICK: Yes. Thank you.

15 Any questions? Okay. Thank you.

16 MR. NATARAJA: So Robert Johnson.

17 MR. JOHNSON: Okay. Good morning. My
18 name is Robert Johnson. I'll be ready in a second.
19 I'm with the Performance Assessment Section, as Raj
20 mentioned. Bear with me.

21 Okay. Again, my name is Robert Johnson.
22 I'm with the Performance Assessment Section in the
23 Environmental Performance Assessment Branch in NMSS.
24 I will be presenting today with persons that have
25 already been introduced.

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1 The key or the purpose or the reason that
2 we're here is to brief you guys about the development,
3 the methodology, and the capabilities of the PCSA tool
4 and to discuss the simplified conceptual analysis that
5 we've started.

6 Thank you.

7 Okay. Once again, the reason we're here
8 is to discuss or brief you guys on the development,
9 methodology, and capabilities of the PCSA tool, as
10 well as discuss the simplified conceptual analysis
11 that we've started to do.

12 The next -- we're also going to provide
13 you a glimpse or some insights on where we're headed
14 with the tool, and some of the things that we need to
15 do to bring it up to speed.

16 Before I get any further, I need to
17 recognize some additional contributors -- Roland Benke
18 at the Center. I didn't mention, Bis is with the
19 Center. In addition, additional contributors are Tony
20 Ebaugh, who is in the High-Level Waste Branch, and
21 Banad Jagannath, and there are a lot of people who
22 have worked along over the course of the development
23 of the tool, a lot of other people.

24 That leads me to the overview. Like I
25 said, I'm going to be presenting the first part of the

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1 presentation today, which is going to provide some
2 background -- the relevant background information and
3 methodology, including relevant requirements, the
4 preclosure safety analysis or safety review strategy,
5 and then outline some of the capabilities of the tool,
6 and then step through the first part of the example
7 problem and the capabilities of the tool.

8 Bis will be up next. He's going to
9 actually provide more detailed information on the
10 conceptual analysis that -- or the example problem
11 that we have put together. He'll outline the future
12 work, and he will provide a summary.

13 Okay. So I'm going to take a minute or
14 two just to step through some of the requirements,
15 just to put it in perspective, so we can better
16 understand what we're doing with the tool. So I'm
17 going to start off the -- okay. Bear with me.

18 Okay. Part 63 defines the preclosure
19 safety analysis as a systematic examination of the
20 site design, potential hazards, initiating events, and
21 the resulting sequences -- event sequences, and the
22 potential dose consequences to both the public and
23 workers.

24 63-112 further defines the preclosure
25 safety analysis as an identification and systematic

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1 analysis of the naturally-occurring and human-induced
2 hazards at the repository, including a comprehensive
3 identification of potential event sequences.

4 The next important point to mention here
5 is the -- that the preclosure safety analysis has to
6 demonstrate compliance with the regulatory performance
7 objectives. And for Category 1 event sequences, which
8 are those that have -- those event sequences that are
9 expected to occur one or more times during the
10 preclosure period. There's a public annual dose limit
11 of 15 millirem, and then the worker dose limits are
12 identified in Part 20 -- are 100 millirem.

13 The Category 2 event sequences, which are
14 those event sequences that are expected to occur at
15 least one time in 10,000 before public -- during the
16 preclosure operation period, has a public dose limit
17 of five millirem per event sequence in the organ dose
18 -- this is just a summary.

19 The preclosure safety analysis is required
20 to identify and analyze SSCs that are important to
21 safety. This analysis should also describe the
22 controls that are relied on to limit or prevent event
23 sequences or mitigate their consequences.

24 It also identifies measures to ensure the
25 availability of the safety systems, and it's also

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1 going to include information on the design basis and
2 design criteria that satisfies the regulatory
3 performance objectives that we discussed up here.

4 Okay. This side provides an overview of
5 the staff's strategy for reviewing a preclosure safety
6 analysis that would be submitted as part of the
7 license application. It's important to note that DOE
8 is required to submit the preclosure safety analysis
9 that meets the requirements that we just discussed.

10 DOE must demonstrate through its
11 preclosure safety analysis that the repository will be
12 designed, constructed, and operated to meet regulatory
13 performance objectives throughout the preclosure
14 period. Key elements of the preclosure review
15 strategy include the fact that the staff will be using
16 the Yucca Mountain review plan to review the license
17 application.

18 Specifically, with respect to DOE's
19 preclosure safety analysis, the staff will use the
20 preclosure safety analysis tool to conduct an
21 independent confirmatory analysis where necessary and
22 to evaluate the preclosure -- DOE's preclosure safety
23 analysis.

24 The staff will focus their review on the
25 important SSCs, or SSCs that are identified as

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1 important to safety, in the context of their ability
2 to meet the preclosure safety objectives. It's
3 important to note that the PCSA tool also -- or is not
4 the only tool that is going to be used to identify
5 SSCs that are important to safety.

6 There is a whole list in 112 that
7 identifies a minimum of 13 other aspects that are
8 going to be considered when they're determining what
9 SSCs are important to safety. Examples of that --
10 means to limit concentration of radioactive material
11 in the air, means to prevent and control criticality.
12 Another example is the ability of SSCs to perform
13 their intended safety functions, assuming that the
14 event sequences occur.

15 The last point here is that staff will
16 look at risk insights for multiple sources. We are
17 first going to be looking at DOE's preclosure safety
18 analysis to make -- to get some risk insights to see
19 it from their perspective.

20 We have our tool, which allows us to
21 independently look at selected portions of a
22 repository or to look at specific systems. We have
23 other similar regulated facilities. We've got --
24 there are multiple sources of input for risk insights.
25 And as I mentioned, one of the main things is that the

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1 tool provides some capability in this area.

2 Okay. The next slide outlines key
3 capabilities of the preclosure safety analysis tool
4 itself. The tool provides independent review
5 capability in that it allows the staff to evaluate the
6 completeness of DOE's preclosure safety analysis,
7 including the identification of hazards, initiating
8 events, the development of event sequences, and
9 consequence analysis, and the identification of SSCs
10 important to safety.

11 It also allows the staff to evaluate
12 selected portions of DOE's preclosure safety analysis,
13 their assumptions, their data, as warranted.

14 Okay. Use of the tool also enhances the
15 staff understanding of DOE's preclosure safety
16 analysis by giving the staff an integrated tool that
17 provides the capability to conduct preclosure safety
18 analyses for part of all of the facilities, as I've
19 mentioned -- selected sections, if we need to, or we
20 can -- we have the capability to do a more exhaustive
21 analysis.

22 It allows us to perform independent safety
23 -- an independent safety assessment. It allows us to
24 look at the event sequences and independently identify
25 SSCs important to safety. It allows us, as I

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1 mentioned, to develop preclosure risk insights,
2 perform sensitivity and importance analysis, provide
3 -- and one of the main things is that it provides a
4 framework -- the staff with a framework for
5 systematically documenting our review.

6 Okay. This slide is a graphical
7 representation of the staff's preclosure safety
8 analysis review methodology as described in the Yucca
9 Mountain review plan. Each of the individual boxes
10 which are kind of hard to read here are -- they
11 represent particular elements of the staff's review
12 included in the YMRP, in the reference sections of the
13 YMRP. I tried to identify which sections related to
14 it in each of the boxes, so it's easy to understand.

15 Okay. To illustrate the relationship
16 between the preclosure review methodology and the PCSA
17 tool, I further grouped the review methods. Okay.
18 The first box actually represents the inputs to the
19 PCSA tool, the things that we're going to be inputting
20 into the tool itself.

21 That includes a site description, facility
22 design and operations, the SSC design bases that we'll
23 have, and identify inputs from naturally-occurring and
24 human-induced hazard analyses.

25 Okay. The next grouping actually

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1 represents the functions that are going to be taken
2 care of in the PCSA tool, or the PCSA tool functions
3 themselves and how they relate to the review method.
4 These include operational hazards, event sequence
5 analysis, and categorization consequence analysis,
6 compliance assessment for Category 1 and Category 2
7 events, and the identification of SSCs important to
8 safety.

9 And the last grouping represents the
10 objectives of the preclosure safety analysis itself,
11 and that includes, again, the compliance assessment
12 for Cat. 1 and 2 event sequences, and the
13 identification of SSCs important to safety, as well as
14 a review of design basis and design criteria, and a
15 review of ALARA requirements 20 for Cat. 1 event
16 sequences.

17 Okay. This slide provides a brief
18 introduction, a simplified conceptual analysis that we
19 have been working on, or the example problem. There
20 has been a recent increase in staff emphasis on both
21 the preclosure safety analysis itself and the
22 preclosure safety analysis tool. And one of the
23 results is the analysis that Bis is going to discuss.

24 Activities that were performed as part of
25 that analysis include we went through and created a

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1 conceptual dry transfer facility. In the absence of
2 real design information, we actually laid out what we
3 expected to be in the facility and started from there.

4 We went through and identified applicable
5 functional areas. We performed hazard analyses,
6 FMEAs, and what-if type analyses, developed event
7 trees, assigned hypothetical probabilities for
8 initiating and top events in the event trees. We went
9 through and identified Category 1 and Category 2 event
10 sequences.

11 And then, with the results, we compared
12 the doses from each of the Category 1 and Category 2
13 event sequences to their respective performance
14 objectives in 63-111. We identified some hypothetical
15 SSCs that are important to safety and performed a
16 limited risk analysis, because the scope of this
17 analysis was relatively small.

18 One thing to understand here -- the list
19 that I just went through is not intended as a -- or
20 it's intended as a higher level discussion to lay the
21 foundation for the more detailed discussion that's
22 going to be coming.

23 And the last point is that the staff is
24 going to be using a similar approach to review DOE's
25 preclosure safety analysis.

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1 Now, we can transition or we can take
2 questions. Yes, ma'am.

3 MEMBER WEINER: At what point -- if you go
4 back to your last slide with the boxes --

5 MR. JOHNSON: Yes, ma'am.

6 MEMBER WEINER: -- at what point do you
7 introduce the notion of probability or risk in your --
8 in the blue box in the tool itself?

9 MR. JOHNSON: Okay. In the tool itself,
10 the concept of risk is identified. First, we go
11 through and there's sort of a qualitative approach.
12 You start out the process and go through the
13 operational hazard analyses themselves.

14 Then, you're going to identify event
15 sequences that are within -- or I should say you
16 determine the probability of the event sequences that
17 you've identified here to determine whether they fit
18 within the -- if they are beyond consideration or
19 whether they are Category 1 or Category 2 event
20 sequences.

21 And then, the consequences are determined
22 for each of the event sequences that fit into each of
23 the Cat. 1 and Cat. 2 event sequences, and the
24 combination of the two is I think what you're looking
25 for.

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1 MEMBER WEINER: Do you introduce
2 probability into your -- or do you associate your
3 event sequences or any component of them with
4 probabilities?

5 MR. JOHNSON: Yes, ma'am.

6 MEMBER WEINER: I suppose I'll see that in
7 the example.

8 MR. JOHNSON: Yes.

9 MEMBER WEINER: Thank you.

10 MR. JOHNSON: Were there other questions?

11 MEMBER HORNBERGER: Do we know how DOE is
12 going to do their analysis for the preclosure case?

13 MR. JOHNSON: At this point, we know that
14 -- we have some understanding. They've put out a
15 preclosure safety analysis guide. It's my
16 understanding that there's going to be a revision to
17 that coming up or coming out in the near future. I'm
18 not sure when that's coming out.

19 Do you have anything maybe to add to that?

20 DR. DASGUPTA: Well, we have seen their --

21 MEMBER HORNBERGER: You have to use a
22 microphone.

23 DR. DASGUPTA: This is Bis Dasgupta. We
24 had a glimpse of their analysis for the IRSR design,
25 but their change of the design and the new analysis we

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1 haven't yet seen.

2 MEMBER HORNBERGER: So based on what you
3 know, how similar or different do you anticipate that
4 the DOE safety case would be from your method of
5 analysis, your PCSA tool for example?

6 DR. DASGUPTA: DOE -- we have this tool to
7 review DOE's preclosure --

8 MEMBER HORNBERGER: Yes, I realize that.

9 DR. DASGUPTA: -- analysis. And they can
10 present their -- I mean, their analysis the way we'd
11 like. And we have our own approach to review that.

12 MEMBER HORNBERGER: Right.

13 DR. DASGUPTA: Hopefully, it's all in the
14 same direction. But today what I'm going to talk to
15 you about, how we are going to approach that.

16 MEMBER HORNBERGER: Okay. So I realize
17 everything that you just said, and I accept it. But
18 what I was trying to gain some understanding of is
19 whether your anticipation is that there will be any
20 major differences between the way DOE approaches the
21 building of their safety case and the way you have
22 organized to review the safety case.

23 DR. DASGUPTA: As far as the IRSR design,
24 we don't think that there will be -- whatever we do
25 from the IRSR design analysis, I think we are headed

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1 in the right direction. But I do not know if they are
2 changing their methodology for future analysis.

3 MR. JAGANNATH: Banad Jagannath, staff.
4 We reviewed the PSA guidance document, which is
5 related to the staff guidance document, and what we
6 have seen we are in kind of -- same considerations,
7 same logic. We have not seen any detail, but my
8 general impression is we are in agreement.

9 CHAIRMAN GARRICK: Let me ask about an
10 overall strategy here. Has the strategy in developing
11 a PCSA methodology been one of how to review somebody
12 else's safety case or safety assessment, or has it
13 been almost 100 percent an independent method of doing
14 safety assessment? Because the role here is one of
15 satisfying yourself that their analysis is a credible
16 one and has addressed the issues correctly.

17 Can somebody comment on whether or not
18 that -- because we have seen in the performance
19 assessment there is quite a bit of attention given to
20 the perspective of being a reviewer rather than just
21 an independent -- developing just an independent
22 capability to do safety assessment.

23 MR. JOHNSON: That's a good question, and
24 I've got a good answer.

25 (Laughter.)

1 The tool, first and foremost, is designed
2 as a review tool. But it actually allows the staff
3 the capability and the framework to actually do a
4 full-blown analysis.

5 So it's -- we have to review what DOE
6 provides us, the preclosure safety analysis that they
7 provide us. The tool we think is headed in the right
8 direction to allow us to look at their -- the
9 direction that they're headed with the preclosure
10 safety analysis, the methodology document.

11 But the key here is that it actually --
12 the tool gives a little more flexibility. It gives
13 the ability to do the analysis, and then we also can
14 consider some elements of risk. We can go through and
15 incorporate all of the capabilities of SAPHIRE. It
16 allows us to review what they're going to provide, and
17 we -- and actually do an analysis, either a selected
18 portion if it's necessary or a full-blown analysis.

19 CHAIRMAN GARRICK: Okay.

20 MR. JOHNSON: Does that take care of your
21 question?

22 CHAIRMAN GARRICK: Yes, thank you.

23 Do you have any questions? Any other
24 questions at this point? Okay. Thank you.

25 DR. DASGUPTA: Good morning. My name is

1 Bis Dasgupta. The objective of this part of the
2 presentation is to provide you -- provide through an
3 example the overview of the PCSA tool capabilities and
4 how it relates to the review sections that you have
5 seen in the earlier flowchart. I'll go back and forth
6 on that one.

7 To put into perspective, the basic
8 functions of the PCSA tool is to store information and
9 data systematically, conduct wide-ranging qualitative
10 and quantitative analysis, and produce a focused
11 result to determine the compliance with respect to the
12 performance objectives and also to gain risk insight.

13 Now, the structure of the PCSA tool and
14 its module is given in the backup slide, and I believe
15 it's in the slides 4 and 5. The tool actually puts
16 together many analysis techniques, methodologies, and
17 tools in a combined and integrated software. But the
18 tool is very comprehensive, and it has the flexibility
19 to -- with a built-in flexibility to review -- to do
20 review of the preclosure safety analysis, and as well
21 as conduct independent uncertainty, sensitivity, and
22 importance analysis.

23 The staff has conducted a limited
24 preclosure safety analysis on a conceptual dry
25 transfer facility. We looked into -- the focus of

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1 this analysis was to gain experience over the
2 preclosure safety analysis tool, and we looked into
3 the transfer of the assemblies and the canisters in
4 the hot cell, the canister in this hot cell, and also
5 the transfer -- or the handling operations of the
6 waste packages in the welding area. And this is
7 indicated by this circle.

8 Now, the overall conceptual surface
9 facility that we have used in the analysis is given in
10 the backup slide 6. This is the -- this slide shows
11 the operations that have been used in the conceptual
12 analysis. On the left it is -- a bridge crane is used
13 to lift the canisters out of the transportation cask,
14 and before it's put inside the waste package is put
15 temporarily in the staging rack. And then, from the
16 staging rack it is put in the waste package.

17 There is -- an assembly transfer machine
18 has been visualized over here kind of to transfer the
19 assemblies one at a time from the transportation cask.
20 The spent fuel is in place from the transportation
21 cask and put directly into the waste package.

22 Now, over here the layout and the
23 operations in this conceptual analysis is in this --
24 you know, the data that was -- the layout and the
25 operations is totally conceptual. And the data

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1 required for this analysis was either assumed or it
2 was taken from the DOE's site recommendation design.

3 Now, the way the preclosure safety
4 analysis tool, or the PCSA tool, would work is that
5 the first -- the whole facility is divided into
6 several functional areas in order to focus our
7 attention on that particular analysis.

8 And that's why you see these different
9 numbers. We give different numbers to these
10 functional areas. That helps us to kind of identify
11 which are we are really agreeing on conducting our
12 analysis.

13 The information for this analysis really
14 comes from the review of these two boxes in the Yucca
15 Mountain review plan sections, such as associated
16 design and operations and associated design basis.
17 The Yucca Mountain review plan in its sections -- site
18 description, facility design, and operations -- we
19 review the information and try to find out the
20 sufficiency and adequacy of the information to conduct
21 a preclosure safety analysis.

22 After having done that, after we are
23 satisfied that we have enough information, those
24 information are abstracted and put inside the -- as an
25 input to the PCSA tool.

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1 Now, after that information has been put
2 in, then we get into the analysis in -- the preclosure
3 safety analysis. That means address the risk
4 triplets, the three sections of the risk triplets.

5 The first one -- the first risk triplet is
6 the operational hazard analysis. The tool has three
7 or four methodologies. These are primarily
8 qualitative techniques, like what if analysis
9 techniques, the failure modes and effects analysis
10 technique, and the -- there is the energy checklist
11 method, and also a human reliability analysis
12 technique has been written. So that the primary aim
13 is to find out the gaps in the identification of
14 hazards and initiating events.

15 Now, for natural and human-induced
16 hazards, these are reviewed outside the tool, but the
17 credible hazards are primarily -- the information on
18 the credible hazards, primarily the frequencies are
19 put inside the tool as an input, so that that can be
20 used for further analysis.

21 MEMBER WEINER: Excuse me.

22 DR. DASGUPTA: Yes.

23 MEMBER WEINER: Could you identify as you
24 go through this where you have hardwired something
25 into the tool and where it is a user input? Just for

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1 my information, if that's not too much trouble.

2 DR. DASGUPTA: Oh, no. Yes. Probably
3 I'll -- that's the basic -- I mean, that's the
4 objective of this sort of talk, to kind of go hand in
5 hand and to show you what we have done in the tool and
6 how the tool relates to the review process and what we
7 are going to input that.

8 Okay. To go back to answer your question,
9 the first thing is to -- that we have, we first have
10 to input the information in the tool that comes from
11 the review of these high description facility design
12 operation and SSCs design basis. The tool has gone --
13 first, the system description component, and included
14 -- in addition to that, the types and the quantity of
15 the nuclear material that's going to be sort of used
16 in that particular functional area.

17 So the first is all divided into
18 functional areas, and information for each functional
19 area then comes through from the review of this
20 process again.

21 The tool takes this information, and then
22 the first step of the tool is to conduct a hazard
23 analysis. And I just said that -- what are these
24 different hazard analysis techniques that we have
25 built into the tool?

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1 So the tool has the capability of
2 conducting the total hazard analysis. But, of course,
3 we will get from DOE a list of hazards. The idea over
4 here is to find the gaps in their hazard analysis and
5 to identify whether they have not included some of the
6 hazards and analyzed them in the -- you know, further
7 analyzed them to determine the compliance and the
8 risk.

9 So now the -- in this example, the hazard
10 analysis was conducted, and I think the backup slide
11 number 7 shows you the list of hazards that has been
12 identified for this simple conceptual facility.

13 The primary hazard that we have identified
14 over here are the assembly drop and the canister drop,
15 because of the failure of the bridge crane or the
16 assembly transfer machine, or due to the human errors.

17 Okay. After the hazard analysis -- after
18 the identification of the hazards, the next step in
19 the -- the next component of the risk triplets is the
20 event sequence analysis and categorization. The tool
21 -- that means over here the tool now does its own
22 analysis, which means tries to develop the scenarios,
23 event scenarios. For doing this analysis, we need the
24 event scenarios.

25 Event scenarios are defined as the

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1 initiating events and the subsequent failure of layers
2 of protective and mitigative safety systems that have
3 been designed to protect the workers and the public
4 from getting the radiological dose.

5 So which means now -- I think I can turn
6 this off. Which means the scenarios are then
7 developed into event trees, and the tool has the
8 SAPHIRE software to do the event tree and the fault
9 tree analysis that we were required to use as the
10 probability data that I think a little while ago you
11 have been talking about.

12 Okay. The example that we saw has got --
13 the scenarios have been identified in slide number 10,
14 I think, in the backup slides. And over here what I'm
15 showing is just an example of one scenario, which
16 deals with the failure of a bridge crane, which drops
17 the canister, and the canister can breach if it has
18 got an initial defect of certain probability.

19 And after that breach, the public can
20 either get the dose, which is the unmitigated dose,
21 the particulates and the noble gas, or if the HEPA is
22 working the public can still get the mitigated dose,
23 which is coming from the noble gas.

24 MEMBER WEINER: Where do you get -- I
25 assume these numbers are just for your example.

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1 DR. DASGUPTA: Right.

2 MEMBER WEINER: But where will you get
3 these probability numbers from?

4 DR. DASGUPTA: Okay. For this initiating
5 event, we have given -- in this example, we had done
6 some assumptions, and also some -- have also conducted
7 some analysis. For this particular event scenario,
8 the bridge crane failure rate, we got it.

9 We have done independent fault tree
10 analysis, in which we kind of looked into the failures
11 of different components -- electrical and mechanical
12 components, developed a fault tree, and tried to
13 develop the failure rates of the bridge crane. And
14 then we know how many operations are going to be there
15 in that particular --

16 CHAIRMAN GARRICK: Bis, is this for a
17 particular category of bridge cranes, or is this
18 bridge cranes?

19 DR. DASGUPTA: It's a bridge crane. You
20 know, the heavy-duty, because the canisters are
21 primarily the very heavy -- you know, it's a heavy-
22 duty bridge crane, yes.

23 VICE CHAIRMAN RYAN: Just a quick
24 question, too. These are point values for
25 probabilities in this example. Can you also handle --

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1 DR. DASGUPTA: Right.

2 VICE CHAIRMAN RYAN: -- distributed values
3 or --

4 DR. DASGUPTA: Exactly.

5 VICE CHAIRMAN RYAN: -- probability
6 functions?

7 DR. DASGUPTA: Right.

8 VICE CHAIRMAN RYAN: Yes, okay. Thanks.

9 DR. DASGUPTA: The SAPHIRE software can
10 handle distributions for each of these probabilities,
11 and it can propagate to uncertainties all the way
12 through.

13 And for the canister breach, we have
14 assumed this value of 10^{-3} as, you know, initial
15 defects in the canister. The HEPA is -- again, we
16 have assumed it, but it is kind of in the ballpark
17 figure that we -- we see the values in the literature.

18 But all of these values will be looked
19 into in details when the license application comes, or
20 between -- between the license application comes and
21 now we will get into more details in these values.

22 So after we -- this event sequence,
23 although this is a very simple one, but we can use
24 SAPHIRE software to do this analysis. And we will get
25 these event frequencies for each branches of this

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1 event tree.

2 Okay. The next step of the -- of this
3 analysis, of the risk triplets, is to evaluate the
4 consequence, radiological consequence. We use -- in
5 the tool we use RSAC software to do the radiological
6 consequence. And also we use the MELCOR software.

7 The RSAC software calculates the
8 atmospheric dispersion, and the MELCOR is used to
9 estimate the building retention of release of the
10 airborne material, which means it calculates the
11 release fraction. They use a fraction of the release
12 that really goes out to the public. I mean, we are
13 trying to make this analysis more realistic as
14 possible.

15 The tool has the capability to do both
16 point estimate as well as probabilistic analysis of
17 the consequence. And in the probabilistic analysis,
18 the two samples -- a wide range of input parameters
19 like meteorological data, the release fractions,
20 source term event tree, the inhalation ingestions and
21 submersion data, and then the tool uses the RSAC for
22 deterministic analysis for the -- for all of the
23 realizations for different -- for each realization.

24 And ultimately, the tool will produce this
25 kind of results. It will give you complimentary

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1 cumulative distribution function, and this shows -- on
2 the left-hand side it shows the different pathways --
3 the inhalation ingestions for the internal dose and
4 the ground surface and submersion for the external
5 dose and the TDE, the total dose equivalent for the
6 mean dose over here. And we use the mean dose to do
7 a compliance analysis, which you will find over here.

8 Coming back to this one, these are the
9 mean doses that comes from the consequence analysis.
10 We have one step before that. First of all, after we
11 get these frequencies, the frequency needs to be
12 categorized as to the definitions of the Part 63 in
13 which Robert has talked to you about. And these are
14 the categories of the frequency -- Category 1 and 2 of
15 the particular event scenario.

16 MEMBER WEINER: Are you -- I'm unclear as
17 to what you are assuming about the release fractions
18 and the size of stuff that's released and the division
19 between gas and volatile, and so on. Is that
20 somewhere in your code, or do you -- how do you
21 determine that?

22 DR. DASGUPTA: Well, the code as such is
23 -- this is the input that -- you will have to give it
24 to the court.

25 MEMBER WEINER: Yes. But is there a place

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1 that you input, for example, different deposition
2 velocities for your particles, different types of
3 physical or chemical properties of whatever is
4 released?

5 DR. DASGUPTA: Right. And I think if
6 Roland Benke, who is actually -- who is our HB help
7 over there, if you can elaborate on that, Roland.

8 MEMBER WEINER: Okay.

9 MR. BENKE: Sure. This is Roland Benke,
10 CNWRA staff. The answer is yes. Specifically,
11 deposition velocities would be an input to the RSAC
12 code. That would be atmospheric dispersion
13 calculations. The other question that you asked about
14 particle sizes, that is an input for the MELCOR code
15 that's used for building retention fraction, or it's
16 commonly called as leak path factor.

17 Do you have any further questions?

18 MEMBER WEINER: Oh, I will from time to
19 time.

20 (Laughter.)

21 MEMBER HORNBERGER: So that's, of course,
22 the calculation once you have a release. So somewhere
23 in here you've dropped the cask. Tell me how -- what
24 the assumptions are about how much of the material
25 gets released.

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1 DR. DASGUPTA: Did you get that, Roland?

2 MR. BENKE: Oh, okay. Roland Benke again.

3 Sure, yes, I'll -- Roland Benke, CNWRA staff.

4 Starting with the assumption that there is a breach of

5 the cask, we are going to have to pick a release

6 fraction from the spent nuclear fuel that's damaged.

7 In general, we've done a literature search

8 and gathered information from both American National

9 Standards on release fractions for non-reactor

10 facilities, as well as NRC guidance, such as Spent

11 Fuel Project Office Interim Staff Guidance 5, and

12 other NUREG guidance documents.

13 Those release fractions from the guidance

14 documents tend to be conservative. In general, we say

15 for a consequence analysis we use best estimates where

16 possible. Releases from containers, without knowing

17 the impact forces and amount of damage, are certainly

18 generic in these analyses today that you've seen.

19 MEMBER WEINER: Do you use -- I'm not

20 familiar with RSAC. Is that just a gaussian

21 dispersion code?

22 MR. BENKE: Yes, that's correct.

23 MEMBER WEINER: What do you do about the

24 area where the workers would be? Because most

25 gaussian dispersion codes blow up as you get close to

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1 the source. What do you do about the near field?

2 MR. BENKE: Right. Very good point. We
3 are not relying on atmospheric dispersion to give us
4 involved worker doses. Our current plans are to
5 perform calculations offline specific to that worker
6 dose scenario.

7 There is, you know, in general -- if you
8 have a facility that is a number of kilometers away
9 from a member of the public, the atmospheric
10 dispersion can be used for a variety of releases
11 within the building, because obviously they need to be
12 transported through the air and atmosphere to get to
13 the receptor.

14 Now, if the receptor is a worker, then
15 geometry of where the worker is, are they outside an
16 operating gallery, are they inside a hot cell, are
17 they wearing respiration, are they shielding walls
18 that need to be considered. All of those things are
19 more complex and more unique for each scenario.

20 So what the tool capability will be is
21 establishing the links and areas where information can
22 be stored for offline worker dose calculations. We do
23 not foresee the capability to imagine all scenarios
24 and stylized calculations, so that the tool is doing
25 the numbers -- number-crunching on those.

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1 We imagine analyses that can be tracked as
2 -- together for a worker safety compliance at the end
3 using the tool.

4 DR. DASGUPTA: I'd like to add right at
5 this point we don't have the capability to do worker
6 dose, and that's why you see in this column that they
7 are not calculated. But this is in our next -- I
8 mean, this is the next part of the development that we
9 are working on, to introduce the worker dose
10 calculations into the tool.

11 Any questions on this one?

12 MEMBER WEINER: What kind of assumptions
13 are you making when you calculate the public dose?
14 What kind of assumptions are you making about things
15 like breathing rate? And are those user input to the
16 code, or are those hard-wired in the code?

17 CHAIRMAN GARRICK: Or are they offline?
18 Yes.

19 MEMBER WEINER: Or are they offline? Yes.

20 DR. DASGUPTA: Yes. No, these are input
21 to the code, you know, so -- so it's -- the tool is
22 very flexible. We did as minimum as possible
23 hardwiring in the code. So that even -- even with the
24 release fraction, as Roland said, that -- that we
25 didn't hardwire that, and it depends upon what are the

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1 release fractions or other data that we get -- and
2 review them, and then put that into the code, into the
3 analysis.

4 Now, this was a snapshot of just one
5 example of the different event scenarios that I have
6 listed in the backup slide, which is slide 9. So,
7 similarly, we go through this analysis, and for each
8 of these event scenarios the initiating event
9 frequencies and the other probabilities -- you know,
10 particularly the initiating event frequencies -- are
11 given in slide number 10.

12 So we go through this analysis. The tool
13 goes through this entire analysis, and for different
14 functional areas -- and then the results of all the
15 event sequences, the frequencies, and the
16 consequences, are all put together from the entire
17 repository, and they are collected in one place.

18 This slide shows the only -- the
19 Category 1 event sequences. They are kind of soldered
20 -- all of the Category 1 event sequences. And here is
21 the compliance analysis that the tool performs.

22 First of all, I think Roland has touched
23 upon the different compliance assessments that we go
24 through. Number one is that individual event
25 sequences should not be greater than 15 millirem.

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1 Okay? That's number one compliance assessment.

2 The second one is the annualized dose or
3 the frequency weighted dose should not exceed, again,
4 15 millirem per year.

5 And the third one is the -- some of the
6 dose from combination of events in a single year also
7 should not exceed 15 millirem.

8 I did not show that analysis, but the tool
9 has the capability to do the combination of events
10 over here, so you hit -- when this calculation is
11 done, it gives all different possible combinations of
12 different -- of Category 1 event sequences and the
13 dose. So we comply and look at the compliance from
14 that perspective.

15 This is the compliance analysis for
16 Category 1 event sequences. Category 2 is quite
17 simple -- that their regulation says that each
18 individual event sequence should not exceed five rem
19 dose criterion. So -- you know, so we don't need to
20 do any further analysis to that one.

21 The next is the example of SSC important
22 to safety. This feature is not fully functional in
23 the tool, but this is the methodology that probably
24 you will use. This is based on our take-away
25 approach, take-away analysis approach.

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1 Again, coming back to the same example,
2 this is what we do -- what we will do. We will take
3 this baseline event tree, and then take away the
4 safety system one by one and look at the -- and
5 perform the compliance assessment once again.

6 And then, if the compliance assessments
7 show that it exceeds the regulatory dose limit, then
8 that particular safety system is important to safety.
9 So this is the process of analysis that we will be
10 using to identify SSCs important to safety.

11 Risk analysis. The tool provides the
12 capability to evaluate system risk. Now, this is --
13 this capability has been introduced to gain risk
14 insight.

15 Okay. The tool performs both point
16 estimate and probabilistic risk analysis. A sample
17 result from this risk analysis is given in -- I think
18 in slide -- backup slide 12.

19 What do we expect from this risk analysis,
20 and how do we want to gain risk insight? First of
21 all, the tool evaluates the total risk. It considers
22 all Category 1 and Category 2 event sequences are
23 beyond design basis, so it doesn't distinguish the
24 Category 1 or Category 2. It takes all of the event
25 sequences, and then the total risk calculation is

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1 performed.

2 This result from the risk analysis --

3 MEMBER WEINER: Excuse me. How do you --
4 do you multiply the probability times the consequence
5 and then add them all up? Or how do you do that?

6 DR. DASGUPTA: Well, it's -- I think I
7 will have to again defer to Roland Benke. But we do
8 in a probabilistic space. It's not just
9 multiplication of our frequency times the dose. It's
10 -- we do this calculation in the probabilistic space,
11 and find out the outcome of each event -- occurring
12 and non-occurring -- and combinations of those
13 different events occurring. So you would get a big
14 list of different combinations of events.

15 Roland, do you want to add anything to
16 that?

17 MR. BENKE: Yes. Roland Benke, CNWRA
18 staff. At this time, I think we should probably
19 finish the presentation. I could probably talk a
20 while on that, but I don't think it's appropriate
21 right now.

22 What you could do is point them to the
23 paper that's mentioned at the bottom of slide 16 that
24 outlines the methodology. You summarized it well.

25 Thanks.

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1 DR. DASGUPTA: Thanks, Roland.

2 So after obtaining the risk, the -- we try
3 to analyze this and find out what are the largest --
4 what is the risk insight, to try to understand what
5 are the largest contributors of the total risk. It
6 could be based on some certain SSCs functioning or not
7 functioning, or it could be certain functional areas
8 that have a high risk significance.

9 Or it could be any hazards or operations
10 that could be risk significant. I think that
11 information we will get from the risk analysis
12 capabilities.

13 We come to future work. The tool
14 development is not complete. The Version 3 is our
15 target version for -- to be used for the license --
16 for review of the license application. As we have
17 already talked about, the worker dose capability has
18 not been introduced yet, but we are working towards
19 it.

20 Primarily, the worker dose calculation
21 will be done offline, but the tool will develop the
22 input data for dose analysis. And then, the tool will
23 also have the linkages that will come out of the
24 worker dose calculations to do the compliance analysis
25 of the event sequences, and also the SSCs important to

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1 safety related to the worker dose calculations for all
2 of the performance like the tool.

3 We are expecting to use, for the external
4 dose softwares like MCMP, the Monte Carlo software,
5 and also use the dose -- for the internal dose, we'd
6 like -- we probably will use the guidance given in
7 Part 20. So the Part 20 will be heavily used for
8 assessing worker dose calculations.

9 The tool -- our next goal is to do
10 software verification of the PCSA tool. Each
11 individual external softwares will be -- also will be
12 verified, and also the entire process. The PCSA tool
13 itself will be verified.

14 And we would like to continue the safety
15 analysis in the next fiscal year, expand the analysis
16 that we have done, the conceptual design, which means
17 -- analyze the other functional areas or -- and bring
18 in the other hazards, like the external hazards, which
19 has not been analyzed in this particular analysis.

20 In summary, as you can see from the backup
21 slides and all of these discussions that the tool is
22 pretty complex. And it's also very comprehensive.
23 And this tool -- but it had got enough flexibility to
24 do the review, to do its independent analysis, to do
25 reviews.

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1 The tool can do uncertainty sensitivity
2 and importance analysis, and it -- you know, it
3 combines so many different methodologies and the tools
4 and the techniques that makes this tool kind of unique
5 for it to use in the Yucca Mountain -- to review the
6 preclosure safety analysis for the Yucca Mountain
7 facility.

8 And the rest of the summaries are like we
9 will continue -- the staff will continue using the
10 tool in the next fiscal year to gain more experience
11 and also to gain more risk insight. And as more and
12 more details that we receive from DOE, probably we
13 will iterate through that process and analyze them to
14 get ourselves a -- to get insight into the facility
15 operations and design.

16 I think that's all I had.

17 CHAIRMAN GARRICK: Okay. Bis, what is not
18 included in the methodology that would make it a full-
19 fledged PRA tool?

20 DR. DASGUPTA: That's a good question.
21 And we looked hard into it and tried to compare every
22 time what is there in the PRA methodologies and what
23 we didn't have in the tool. My assessment is that we
24 have almost all ingredients that the PRA uses that we
25 have over here.

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1 This tool, although I did not mention,
2 could use -- you know, look at the dependent or common
3 cause failures. This is all built into the kind of
4 scenarios or event scenarios that you can use.

5 Sensitivity uncertainty analyses are all
6 part of this -- you know, the tool functionality over
7 here. So to me, you know, I don't see very much of
8 the difference between the PRA and the total function.
9 We are -- in this tool, we are looking into all
10 aspects of the risk triplets. And that's the sense of
11 both PRA as well as the PCSA tool.

12 But that's my sort of assessment. If
13 anybody else has --

14 CHAIRMAN GARRICK: So, well, we didn't see
15 any examples of common cause or real --

16 DR. DASGUPTA: Right.

17 CHAIRMAN GARRICK: -- dependent failure
18 analysis or uncertainty analysis or human reliability
19 component or --

20 DR. DASGUPTA: Right. But --

21 CHAIRMAN GARRICK: -- what have you. But
22 you're saying that you could introduce a top event,
23 for example, in your event tree that would account for
24 human --

25 DR. DASGUPTA: Right.

1 CHAIRMAN GARRICK: -- reliability, and you
2 could accommodate the split fractions in the event
3 tree with probability distributions, etcetera,
4 etcetera.

5 DR. DASGUPTA: Exactly. And, in fact, we
6 have introduced the human reliability or the human
7 error effects into -- in our example problem. Some of
8 the examples that we had, the human could make an
9 error in trying to lift the canister or the
10 assemblies. While they are lifting it and putting it
11 down, there could be several different ways the human
12 can drop the load. And it's all like error of
13 commission. And that's what he had tried to do that
14 in a very simplified manner in this example itself.

15 The tool -- I did not mention, of course,
16 the tool has a database of different failure
17 probabilities, okay, we gathered from different
18 sources, and the tool has a database of the failure
19 rates, including wherever we could get any information
20 on the uncertainties.

21 And also, it has got the HEP -- or the
22 human error probability generator. It's apparently
23 from the Swain and Goodman's methodology that we have
24 introduced in the tool, so any time people can -- want
25 to evaluate the human error probability they could go

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1 ahead and do it.

2 And the other aspects of trying to
3 identify if human could be an initiator -- we have a
4 qualitative methodology in a hazard analysis
5 technique. We have a process that -- where, you know,
6 the user can go through and evaluate or find the human
7 errors that can initiate events. Or if human error
8 could be used in the fault tree or event tree
9 analysis, you know, it's all built into that.

10 CHAIRMAN GARRICK: Now, how about data
11 updating such as the use of Bayesian methods to
12 account for new data.

13 DR. DASGUPTA: Right.

14 CHAIRMAN GARRICK: Are there any
15 algorithms for that?

16 DR. DASGUPTA: No. Right now, we don't
17 have, but we have plans to work on that. We do --
18 because that's our next step in the steps that we will
19 be following in this coming fiscal year.

20 CHAIRMAN GARRICK: Ruth.

21 MEMBER WEINER: I have two questions right
22 now. One is, how do you do -- you said you can
23 propagate a distribution of any input variable. How
24 do you sample on that distribution? And do you allow
25 the user to choose a sampling method -- Monte Carlo,

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1 SAPHIRE, and so on?

2 DR. DASGUPTA: Yes. For the frequency
3 analysis, the SAPHIRE does that and the SAPHIRE has
4 got both these methodologies -- Monte Carlo and LHS --
5 so, you know, the user can choose whichever sampling
6 process they can use.

7 MEMBER WEINER: The other question is:
8 did you -- when you chose SAPHIRE, did you look at a
9 variety of software tools that could accomplish this?
10 Because just -- I don't really know much about your
11 tool, obviously, since this is the first time I've
12 seen it.

13 But it seems to me that Analytica, for
14 example, can do most of what your tool does without a
15 lot of extra design. I just wondered if you had done
16 a survey of software before settling on this
17 particular approach.

18 DR. DASGUPTA: Yes. And there were two
19 criterias for it. One was research. We looked into
20 different software. And the other -- while doing
21 that, we found out that SAPHIRE is kind of in a very
22 developed stage compared to, you know, a couple of --
23 even a couple of years back. And SAPHIRE is actually
24 developed for NRC. So SAPHIRE is software NRC uses
25 quite a lot and NRC has confidence in.

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1 CHAIRMAN GARRICK: The normal approach
2 that is taken in most PRA work is that you -- of
3 course, once you get the scenarios and the likelihoods
4 of the scenarios in whatever form you have them,
5 either as frequencies or probabilities or probability
6 of frequencies, or whatever, you often do this just on
7 the basis of point estimates.

8 And then, when you see which of the
9 scenarios are the most interesting from the standpoint
10 of contributing to risk, then you magnify the level of
11 the analysis considerably on those particular ones,
12 and including probably the invoking of a bona fide
13 uncertainty analysis.

14 Is that something -- is that a practice
15 that you would tend to follow?

16 DR. DASGUPTA: Yes. Yes. That's exactly
17 -- and the tool actually has that flexibility. Why
18 I'm saying this is supposing we chose one particular
19 event scenario, and we went through this point
20 estimate analysis. So that's the first pass of the
21 analysis.

22 And after the analysis has been conducted,
23 and if you want to do sensitivity on that particular
24 event scenario, the tool does not -- I mean, you don't
25 have to delete that scenario from that. And you could

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1 still develop another parallel scenario, do the
2 analysis, and use the new analysis for your compliance
3 assessment.

4 And in that one, we could bring in the
5 uncertainties and sensitivity and all other different
6 parameters that we know of. And this is the kind of
7 risk insight is that we are planning -- hoping to gain
8 from this tool.

9 So as of now, we have tried to build in as
10 much as we can think of. And probably in the next
11 year when we do more analysis, and as we go through
12 this process, there may be certain changes we need to
13 make. But to exactly sort of keep these
14 flexibilities --

15 CHAIRMAN GARRICK: I think the important
16 thing is to make sure that the analysis only is as
17 complicated as it needs to be. There's a lot of
18 scenarios associated with this kind of a system that
19 you can eliminate in a very quick hurry, just by
20 looking at the scenarios in many instances.

21 And you certainly don't want to employ the
22 full rigor of the process on each of the scenarios,
23 and I'm assuming that that's how you will -- how you
24 would use it.

25 DR. DASGUPTA: Right. I mean, yes, the

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1 level of --

2 CHAIRMAN GARRICK: The exercise of going
3 through and developing the scenarios very often is the
4 most valuable exercise in terms of relating the model
5 to the physical characteristics of the facility. Once
6 you do that, generally a lot of things become pretty
7 obvious and you can narrow the scope of the problem.

8 Doing it in phases like that is extremely
9 valuable, and I assume that's what you will do. You
10 won't apply all of the rigor of your software to each
11 scenario.

12 DR. DASGUPTA: You are right, and that
13 will be built into the tool, not to go to all -- for
14 example, we may not want to do a rigorous hazard
15 analysis if we know there's only a handful of hazards
16 that we need to look at.

17 CHAIRMAN GARRICK: Yes.

18 DR. DASGUPTA: Okay. So the tool -- you
19 don't have to go from one end of the analysis to the
20 other end. You can get in, develop your event
21 scenarios, you can just go in and do your sequence
22 analysis, but all -- at the end, the tool allows you
23 to systematically put this data in a place, so that
24 ultimately you can do your compliance assessment.

25 I hope I answered your question.

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1 CHAIRMAN GARRICK: Yes. Any other -- this
2 is an unfair question to close out this discussion on,
3 but I'll ask it anyhow. Given that you have now taken
4 basically the ISA thought process and evolved it into
5 what appears to be almost a PRA format, if you had it
6 all to do over again would you not consider just
7 starting with a PRA established model?

8 DR. DASGUPTA: Well, to me, the only
9 component of the ISA, as far as I understand about
10 ISA, is the hazard identification part that we have --

11 CHAIRMAN GARRICK: Yes. But that's part
12 of my point, Bis.

13 DR. DASGUPTA: Yes. And, in fact, when
14 the PRA -- it's my understanding, I mean -- I came to
15 this line much later, but my understanding is that
16 when PRA was started, ISA or these hazard analysis
17 techniques were not there. They came later on,
18 primarily with the chemical industry.

19 And so we have added this facility. I
20 mean, it's not that -- we kind of added this
21 capability to do this qualitative hazard analysis to
22 identify certain hazards. So beyond that, all of the
23 analysis is primarily PRA-based in the tool. So
24 that's the only part that we really borrowed from the
25 ISA.

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1 CHAIRMAN GARRICK: All right. Well, you
2 can't help but ask the question given that this is
3 kind of the founding agency for PRA, and there was an
4 established legacy of methodology that was not only
5 available but demonstrated with numerous applications,
6 including fuel cycle applications. And I was just
7 curious as to whether or not, if you had it to do
8 over, you would maybe start from a different point
9 than going to the chemical industry and pulling from
10 that resource.

11 DR. DASGUPTA: Yes. Tim has something.

12 MR. McCARTIN: Yes. Tim McCartin, NRC
13 staff. I guess when we put ISA in the rule, in our
14 proposed rule, we weren't implying a suggestion that
15 we were looking at ISA -- a term as a very broad class
16 of analyses. PRA would be considered in that broad
17 class. It was getting more -- and we probably made a
18 mistake, and we -- obviously we did change the name in
19 the final rule.

20 CHAIRMAN GARRICK: I'm sure glad of that.

21 (Laughter.)

22 MR. McCARTIN: Because we weren't -- there
23 was not -- we were not trying to indicate a particular
24 analysis but trying to identify a broad class. And
25 consistent with what you were saying before, you need

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1 to do an analysis appropriate to the complexity of
2 what you're dealing with, and there wasn't an attempt
3 to exclude it.

4 And as Bis has explained, really this
5 particular methodology has really, you know, pretty
6 much all the elements of a PRA in many different ways.
7 So, you know --

8 CHAIRMAN GARRICK: Well, that's enough.
9 Thanks, Tim. I understand, and I just had to needle
10 it a little bit.

11 (Laughter.)

12 Wake people up, you know.

13 All right. Are you finished, then?

14 DR. DASGUPTA: If you don't have any
15 further questions.

16 CHAIRMAN GARRICK: Are there any more
17 questions from staff? From anybody?

18 Okay. Is this a good time, Raj, to have
19 a break?

20 DR. DASGUPTA: Yes.

21 CHAIRMAN GARRICK: Okay. Let's take a 15-
22 minute break.

23 (Whereupon, the proceedings in the
24 foregoing matter went off the record at
25 10:02 a.m. and went back on the record at

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1 10:20 a.m.)

2 CHAIRMAN GARRICK: Okay. Let's see if we
3 can resume. I have been informed that Mark Board
4 wants to make a comment following these next series of
5 presentations, and we want to be sure and allow him
6 time to do that. So we have that on the agenda now.

7 I think I'm going to ask Committee Member,
8 our token geoscientist, George Hornberger, to take the
9 lead on these next presentations. George.

10 MR. HORNBERGER: Thanks, John. So we're
11 going to proceed, and as Raj introduced, we're going
12 to move in now to talk about some engineered barrier
13 performance aspects. And, Goodluck, I think you're up
14 first; is that right?

15 DR. OFOEGBU: Yes.

16 MR. HORNBERGER: Please proceed.

17 DR. OFOEGBU: My name is Goodluck Ofoegbu.
18 I'm here to talk about the evolution of rockfall
19 effects for input to performance and assessment
20 calculations. The approach that I'm going to present
21 today has been implemented in the MECHFAIL module of
22 the TPA 5.0 code that will be described later in the
23 afternoon. I'm not going to talk about MECHFAIL
24 because there's a second presentation that will deal
25 with that, only to point out that rockfall loading of

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1 the engineered barrier components is one of the
2 quantities evaluated in the MECHFAIL code, and the
3 objective in this presentation will be to explain the
4 basis for the evaluation of rockfall that is
5 documented in the -- I mean that is implemented in the
6 MECHFAIL code and documented in their Company report.

7 The first thing I want to do is to explain
8 that there are two aspects of rockfall evaluation.
9 The pre-closure aspect focuses on the stability of the
10 emplacement drifts. We'll look at information
11 available for engineering design of the openings, a
12 combination of some kind of inspection -- to determine
13 if the openings will be sufficiently stable to support
14 the pre-closure operations. And this information will
15 be used as the input in pre-closure safety analysis.
16 And that aspect -- this aspect -- the rockfall aspect
17 of pre-closure safety analysis is not going to be
18 discussed in this presentation. Our focus in this
19 presentation is to look at the evaluation of rock fall
20 to provide input to post-closure.

21 The difference, an important difference
22 between post-closure and pre-closure is that, one. the
23 repository is closed. The openings would no longer be
24 available for any kind of engineering intervention.
25 And any ground support provided during the pre-closure

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1 period would degrade with time and would ultimately
2 lose its effectiveness and suspect that a part of the
3 rock mass surrounding the opening would thereafter
4 likely break into blocks. Some of these blocks would
5 fall into the openings and slowly accumulate as rock
6 rubble. Individual blocks falling into the opening
7 strike the engineer by their components, which are the
8 drip shield, and may deliver some dynamic loading to
9 the component. The components have to be evaluated
10 against their ability to withstand what they will do
11 when subjected to that kind of loading.

12 The dead weight of the accumulated rock --
13 the dead weight of any accumulated rock will wear on
14 the engineered by their components, and their
15 capability to support such dead weight also needs to
16 be evaluated. As the rocks break up from the roof
17 area, they change the geometry of the roof, and as
18 they accumulate in the opening, they also change the
19 geometry. So, ultimately, what's the data say?
20 Opening with an empty space with components may evolve
21 into a mass of rubble, a mass or rubble, and this
22 change in the configuration of the emplacement drifts
23 need to be considered in the calculation of parameters
24 of the near field environment, such as temperature,
25 such as the flow of moisture and maybe other aspects.

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1 So my intention with this one is to explain how we
2 calculate the rock fall inputs into these aspects of
3 performance assessment.

4 And to do that we're going to go through
5 a number of topics. I don't want to dwell on them.
6 I'll go right straight to the first one, which is
7 dynamic rock-block impact on drip shield. Now, the
8 interest in evaluating dynamic rock-block impact is to
9 look at the potential for rock blocks that are large
10 enough to cause damage to the drip shield, striking
11 the drip shield. And the -- because of this in the
12 lower lithophysal stratigraphic unit, which represents
13 the bulk of the rock types that are likely to be
14 encountered in the repository, it has been determined
15 that the rock blocks that would form -- that are
16 likely to form are individually too small to cause any
17 damage as an individual dynamic impact. So because of
18 that, dynamic impact on drip shield is not considered
19 a concern for the lower lithophysal area of the
20 repository.

21 But for the middle nonlithophysal area,
22 there is potential for individual block -- rock blocks
23 that can cause damage. An analysis of the block size
24 distribution of the rock based on fractured data
25 indicates that about 60 percent of the blocks will be

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1 less than one cubic meter. Considering the density of
2 the rock, that's about 60 percent less than 2.5 metric
3 tons. But there is 40 percent that is greater than
4 that, and these need to be considered. About 35
5 percent lie in between 2.5 and about five metric tons.

6 MR. HORNBERGER: Goodluck, the basis of
7 that is just fracture spacing?

8 DR. OFOEGBU: Yes. That is -- well --

9 MR. HORNBERGER: So is there any empirical
10 evidence that blocks of this size actually do fall
11 from openings like this?

12 DR. OFOEGBU: Yes. There is empirical
13 evidence. There have been observations at the site,
14 but we haven't -- the openings that have been there
15 haven't been long enough to contribute the information
16 that can be used to make this a definite number. In
17 the geological engineering field, that's often the
18 approach that is used to estimate block sizes. You
19 look at the fracture distribution, try to take the two
20 dimensional fracture that are collected from openings
21 from outcrops, generalize them into three-dimensional
22 models and try to calculate the size of blocks that
23 would come from such models. So it is a model
24 information, but it is done in a way consistent with
25 the now practice.

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1 CHAIRMAN GARRICK: I guess the key here is
2 the breakaway frequency -- I'll call it breakaway, I
3 don't know what the proper term is. But is there the
4 kind of the evidence that would allow you to even with
5 uncertainty to come up with some sort of a breakaway
6 frequency of rocks as a function of size or size
7 ranges?

8 DR. OFOEGBU: At Yucca Mountain that
9 hasn't been done in practice other than looking at
10 fracture model, but I thought of size before I looked
11 at maybe a place where rock is blasted or something,
12 measure sizes and come up with size distributions.

13 CHAIRMAN GARRICK: Okay. Thank you.

14 DR. OFOEGBU: Okay. But there are two
15 important mitigating factors for dynamic rock-block
16 impact in the middle nonlithophysal area. One of them
17 is the percentage of repository that needs to be in
18 this rock pipe, about 15 to 25 percent at this point,
19 but the information indicates it's going to be less
20 than about 30 percent of the repository that would be
21 -- 30 percent of the emplacement drifts that would
22 encounter this kind of rock.

23 The second one is that the rock blocks
24 would accumulate in the opening, and once the drip
25 shield is buried under the rock rubble, then any of

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1 the rock blocks falling will be falling on top of the
2 rubble and would not be able to transfer significant
3 impact to the drip shield. So because of these
4 mitigating factors, we believe that dynamic rock-block
5 impact needs to be studied but it does not deserve as
6 much emphasis as the next assessment of the part of
7 accumulated rock which we'll go into next.

8 And in looking at all the information
9 available, the drifts -- our observation is that the
10 drifts would be expected to experience rock form and
11 eventually rubble will accumulate in the drifts. And
12 this information is -- this observation is based on an
13 analysis of empirical information from engineering
14 experience and a computation of analysis that has been
15 conducted based on these available designs from the
16 repository.

17 Our engineering experience is that on the
18 ground fractured rock needs ground support system and
19 maintenance of the ground support system to keep them
20 stable and prevent or reduce the appearance of rock
21 fall. And when openings can no longer be provided
22 with the ground support, with the maintained ground
23 support system, such as abandoned mine openings, the
24 experience is that after a certain amount of time such
25 openings collapse. So this forms one of the

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1 contributing basis for the expectation that the
2 emplacement drifts after they are abandoned are likely
3 to collapse and fill with rubble. There have been
4 analysis conducted that also supports the view that
5 ground support systems will be needed to maintain the
6 emplacement drifts in a stable condition, but that can
7 only be done during the pre-closure period. So after
8 post-closure, the expectation is that after an amount
9 of time the openings will go through this experience.
10 There is also DOE information that supports a similar
11 conclusion, a similar observation.

12 MR. HORNBERGER: So these empirical
13 observations, say, in abandoned mines, can you give me
14 an indication of what the empirical data show with
15 respect to, let's say, what fraction of a drift --
16 would nearly 100 percent of the drift be expected to
17 collapse or just in sections?

18 DR. OFOEGBU: Well, the percentage is
19 difficult to estimate based on that experience. And
20 the problem with this is that on the ground rock
21 engineering has primarily been concerned with stable
22 openings. We try to prevent collapse of openings, and
23 once the operation is finished, like in the case of
24 mining, the opening is abandoned. And the only reason
25 people have gone back is where collapse of the opening

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1 has produced a surface expression, such as sinkhole or
2 something or where the opening did not collapse, in
3 which case people can location it like ancient temples
4 in some countries that can locationally go in. But
5 this is only a fraction of the openings that have been
6 constructed, and they don't give information that can
7 be translated in terms of probability.

8 MR. HORNBERGER: Okay. And the second
9 question that occurred to me is, again, in terms of
10 the empirical evidence, is there empirical evidence as
11 to the rates of degradation of the supports, whatever
12 they may be, rock faults in this kind of fractured
13 rock?

14 DR. OFOEGBU: There is empirical evidence,
15 and let's talk about that when we -- I have maybe one
16 or two slides on rates of degradation.

17 MR. PATRICK: If I could interject,
18 Goodluck.

19 DR. OFOEGBU: Yes.

20 MR. PATRICK: This is Wes Patrick, Center
21 Staff. I am probably among the most rank of the rank
22 empiricists, Dr. Hornberger, so I appreciate the
23 comments that you're bringing in on the importance of
24 looking at the empirical evidence. But one of the
25 things -- while encouraging our staff to look at the

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1 empirical evidence and analogs to the proposed
2 repository, one of the problems that we confront
3 immediately is that none of the examples we can find
4 have had the type of thermal cycle that is of interest
5 here. And that is driving this more and more in the
6 direction of while not ignoring the empirical evidence
7 that might be available, for instance, even evidence
8 from the Nevada test site that might be applicable,
9 we're also putting a very strong caution on the use of
10 empirical information because uniquely in the case of
11 Yucca Mountain there will be a cycle where stresses
12 are increased due to a thermal pulse, and then those
13 stresses will decrease over time. And we're going to
14 have to rely more heavily on calculations there I
15 think than we might otherwise like to do, those of us
16 who do tend to take a more empirical approach.

17 DR. OFOEGBU: Okay. Having said that, we
18 have to also take a look at the available empirical
19 evidence and what they tell us about behavior of
20 underground openings in fractured rock, and one of
21 them is being presented here. This was compiled by
22 Barton and a group before this, and what it looks like
23 these openings that are stable, that are known to be
24 stable. The dark circles -- the man-made openings and
25 some of the squares where a few natural openings that

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1 were observed in the study. And this information is
2 plotted against a rating of the rock mass quality.
3 The lowest numbers indicates rock that are badly
4 fractured, and the highest numbers indicates rocks
5 that are less fractured. And what this led to was a
6 kind of line that says that, okay, let me explain
7 this. This one, this panel, the opening is really any
8 dimension of the opening. In the case of a tunnel,
9 for instance, there will be two spans. There will be
10 the diameter of the tunnel and then the length of the
11 tunnel. And considering all those, the information
12 will be issued here and say that the stable openings
13 tend to fall below a certain relationship line between
14 span and rock mass quality.

15 The DOE people have indicated that they're
16 going to use a -- they're likely to use a different
17 approach for evaluating the mechanical quality of
18 Yucca Mountain rock. So because of that, we don't
19 expect that this will be directly applicable, but
20 based on information we have up to the site
21 recommendation analysis, most of that coming from the
22 ESF paper, the rock -- the queue value for the Yucca
23 Mountain rock would fall approximately between one and
24 15, and this is based on taking fractures along the
25 ESF and looking at conditions at every five meter

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1 average or something like that, which would suggest
2 that the maximum span of unsupported opening that one
3 would expect based on this chart would be less than 20
4 meters.

5 The same kind of information, this one, I
6 think, was compiled by Biezenoski based on South
7 African experience and experience from other parts of
8 the world and eventually this matured into a cog that
9 was used for design of underground openings basically
10 to determine at what point do you have to stop
11 construction, go back and install support and then
12 continue, because it's looking at the maximum standard
13 time given a certain span, a certain unsupported span.
14 And this, again, is plotted in terms of rock mass
15 quality. The quality in this is Biezenoski rock mass,
16 which the relationship can be related to the queue
17 values that we showed in the previous chart. But the
18 lower values represent rocks that are highly
19 fractured, and the high values represent rocks that
20 are less fractured. And here the standard time
21 decreases as the span increases. It decreases along
22 the lines such as those board lines. Again, the Yucca
23 Mountain rock would have fallen in the poor rock to
24 fair rock region, maybe a little bit in the good rock.
25 And based on that, the standard time for an

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1 unsupported span of, let's say, two to ten meters, the
2 standard time would be on the order of -- anticipated
3 standard time would be on the order of months and
4 years.

5 This information here, as I said, is often
6 considered conservative, that a number of openings
7 have survived beyond that, but if you were using and
8 constructing a tunnel, for instance, and your concern
9 is providing support so that the rock doesn't fall to
10 hurt people, if you don't have any of that
11 information, it will be considered very somewhat bold
12 to try to go beyond what this chart recommends. But
13 of course the more information you have about your
14 site, then the more able you might be to try to extend
15 beyond what is provided in this design chart.

16 Now, there is an example from a collapse
17 of abandoned mine openings. This study was conducted
18 I think in Bulgaria, was done by a master's degree
19 student, and what they did was look at I think there
20 were 79 occurrences of sinkholes in that area. And
21 how the sinkhole develops this shows schematically on
22 the figure on the right. The figure shows a coal seam
23 and the number of rock layers above and below the coal
24 seam. And, typically, in mining they will cut a
25 section of the coal seam and extract it for economic

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1 purposes, and so when the mining is completed that's
2 what the opening would look like. Then eventually
3 when the mining is done they abandoned the openings
4 and go. The material above the opening will begin to
5 collapse into the opening, and the gradual collapse
6 may at times work its way depending on certain
7 property breaking characteristics of this rock, as we
8 will talk about later. This may work its way to
9 various heights.

10 In this particular case, there is a loose
11 fragment of material above the coal area. And the
12 fragmented material falls into the opening created by
13 the collapse of the abandoned mine opening and
14 eventually produces a surface expression that is
15 called a sinkhole, and it's a problem for highways and
16 buildings and others. So this is why this was -- this
17 phenomenon is of interest and was studied. If it
18 wasn't for the occurrence of the sinkhole, most likely
19 there would be no information about the collapse of
20 the mine.

21 But judging from the time of occurrence of
22 the sinkhole relative to the time that the mine was
23 known to be abandoned, this individual found that the
24 majority of the sinkholes occurred -- about 70 percent
25 of the sinkholes occurred about 60 years after the

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1 mine was abandoned, and about ten percent of the
2 sinkholes occurred about 70 years after the mine was
3 abandoned. So just in this case the occurrence of the
4 sinkholes happened between 60 and 70 years after the
5 mine was abandoned. Now, the occurrence of sinkhole
6 may have been much -- may have been later, I shouldn't
7 say much later. It's possible it occurred at the same
8 time as the collapse of the opening, but it's also
9 possible that it took a long time after that. So what
10 this figure -- this is empirical evidence that
11 suggests to us that the collapse of openings in this
12 kind of rock will take a few tens of years at most.
13 We have to acknowledge that these are not tunnels,
14 these are mine openings. They have a geometry that
15 increases space concentration and makes a geometry
16 that is less stable than the -- geometry, but more
17 important they are also quite large compared to the --
18 the openings are quite large compared to the mine
19 area. So there are factors about these that will make
20 them more susceptible to collapse than other kinds of
21 openings. They haven't said that this is a piece of
22 empirical evidence to go by and if one wants to go
23 beyond these, then the person needs to come up with
24 additional analysis or additional evidence to support
25 extending the time of collapse beyond what is

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1 suggested by this kind of information.

2 MR. HORNBERGER: Goodluck, just so I
3 understand this stuff, the study by Dyne, the 79 cases
4 -- this frequency that you have here refers to 79
5 observed sinkholes; is that correct?

6 DR. OFOEGBU: That is correct.

7 MR. HORNBERGER: So we don't know anything
8 about the population of openings that didn't exhibit
9 sinkholes.

10 DR. OFOEGBU: Well, actually, the
11 population of openings in this area has received a lot
12 of study. We're just showing a sample from a study
13 that was available to us. Unfortunately, this kind of
14 study is not often made available, but there is -- the
15 experience with these kinds of openings and this kind
16 of rock is that they collapse. They are expected to
17 collapse. There may be one or two that survive.
18 Maybe instead of one or two let's say a small
19 percentage that survive, but those are departures from
20 the expected behavior. The expected behavior is that
21 when this opening is abandoned they will collapse and
22 they do -- they may progress to the surface and
23 develop a surface expression. In fact, put the other
24 way, it's only those that develop a surface expression
25 that we are going to see.

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1 MR. HORNBERGER: That's correct.

2 DR. OFOEGBU: The majority of them will
3 probably end up here and maybe have a stiff material
4 here.

5 MR. HORNBERGER: Right.

6 DR. OFOEGBU: So the surface expression
7 doesn't develop.

8 MR. HORNBERGER: Right. But in this case
9 am I right in assuming that these are sort of pothole
10 sinkholes and not linear features? That is, that the
11 whole drift here that collapses a very long segment or
12 is just a surface expression of a part of a drift?

13 DR. OFOEGBU: This is a surface -- well,
14 now, let's learn something. The figure to the right
15 is also schematic explaining how this type of thing
16 develops. The actual study is on the left, and that
17 study doesn't really explain. What happened in this
18 case is that a large mine or a large area over a large
19 mine and these sinkholes usually occur as isolated
20 holes within that area.

21 Okay. Now, going into analytical work,
22 this is an analysis that we conducted a few years ago
23 on pre-closure to try to estimate pre-closure
24 stability. The information used for the analysis was
25 taken from information that DOE -- was derived from

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1 information that DOE used to support its site
2 recommendation. The design is the EDA design, EDA II
3 design, which the drifts are 85 meters center to
4 center from each other, and the diameter is 5.5
5 meters. The drifts are located at a depth of about
6 250 meters below the ground surface. So this analysis
7 was extended to a time of 150 years. The only
8 significance of the time here is the rate of decay of
9 heat produced by nuclear waste.

10 We also looked at the effect of decreasing
11 -- the rock mass strength here has two components:
12 The cohesive component and the frictional component.
13 We looked at the effect of decreasing the cohesive
14 component along a hypothetical time decay occurs, from
15 100 percent of its value at time zero to about 50
16 percent of its value at time in 150 years. The time
17 scale here really is not significant. It is the
18 amount of decay that we were interested in.

19 Now, what this shows is that -- now, let
20 me explain. This analysis is a continuing type of
21 analysis and it was done using a continuum model of
22 the rock mass. And continuing models such as this are
23 enough to identify the onset of failure but they are
24 not really known for calculating the extent of
25 failure. Typically, these kind of analyses are used

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1 to determine the need for ground support systems,
2 because the experience is that if you support that
3 rock that is shown to have -- to be likely to fall,
4 then if you can prevent failure of that, then it would
5 attend the rest of the rock mass. On the other hand,
6 the failure of that rock is not prevented, then the
7 failure is likely to progress layer by layer and eat
8 its way into the rock mass. That progressive growth
9 is not shown here. The model used for this analysis
10 is not capable of calculating that.

11 Wherever we see an inelastic strain it
12 indicates where fracture in rock, and that's an
13 interpretation, fracture in rock is likely to occur.
14 And the common interpretation that usually comes out
15 of this kind of analysis is to say, okay, we need
16 ground support extending into the rock in certain
17 circumstance in order to prevent failure of the
18 fracture zone that was observed in the model. And
19 because of that, the conclusion we can draw from this
20 analysis is that ground support will be needed to
21 maintain stable openings for this particular design
22 and set of properties that we looked at. And the
23 other conclusion, of course, is that when it is no
24 longer possible to provide and maintain ground support
25 system, then we should expect the openings to

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1 experience rock fall and the accumulation of rock
2 insight.

3 There is another example from DOE
4 analysis. This is a different kind of modeling. It
5 tries to represent the rock mass using a set of
6 polygons, and the contacts of the different polygons
7 is assigned a strength and stiffness, and this is sort
8 of tuned such that the overall behavior of the rock
9 model is similar to the expected overall behavior of
10 the rock mass. And a measure -- one important
11 advantage of this kind of approach is that it's able
12 to model failure, it's able to look at progressive
13 failure and you're able to see the extent of failure
14 and extent of failure calculated from the model and
15 also the accumulation of rock within the opening.

16 In this particular case, what DOE was
17 looking at again is the effect of decreasing cohesion
18 to look at potential rock degradation. The rock
19 strength is again represented -- the rock strength has
20 two components -- The cohesive component, the
21 frictional component. And they decrease the cohesive
22 component from each -- one represent of each value in
23 stats of 20 percent. By that it's 80 percent, 60
24 percent, 40 percent, 20 percent and zero percent
25 cohesion. And they looked at the accumulation of rock

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1 in the opening. The one conclusion that we can draw
2 from this study is that as the rock degrades we should
3 expect the openings to experience rock fall and expect
4 rock to accumulate inside the openings.

5 Now, having going through all these
6 calculations, we've reached an expectation that the
7 openings over time will collapse. But what we really
8 need is a way to calculate the amount of rock that can
9 accumulate in the openings and the rate at which this
10 accumulation would occur. Each of -- I show several
11 models -- well, examples from different model
12 calculations. Here are several of the examples. And
13 each of them is able to calculate something that
14 others are not able to calculate. So it's -- taking
15 the information directly from a single model, it's
16 often not a way to do this. You need to draw some
17 conclusions and try to represent those conclusions in
18 an abstracted model that is then used to calculate the
19 quantities that are needed.

20 Doing geomechanics modeling is like
21 looking into a big house through a window. Each view
22 -- each window gives a view of the house, and still
23 the challenge is putting several views together to
24 develop an image of what interior of the house will
25 look like. If one relies on one view, it's quite

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1 possible to come up with a calculation that may be in
2 error. So we've made the observation that openings
3 are likely to collapse. We need to calculate rate of
4 collapse and the amount of material accumulated as an
5 important property of broken rubble that can be used,
6 that when a piece of rocks breaks from the roof and
7 falls, that it's likely -- not one piece of rock but
8 a collection of rock pieces, they are likely to occupy
9 more volume than they occupied within the rock mass.
10 And this -- so as the material falls, more space is
11 created, but the amount of space that the fallen rock
12 occupies increases faster than the new space -- the
13 amount of new space being created. So, ultimately,
14 this increase in volume behavior or bulking behavior
15 of rock has a property of arresting the progressive
16 failure. Because when there is no space for rock to
17 go into, the failure process has been stopped. So by
18 using that, we are able to develop a mass balance
19 approach that simply says that the mass of rock in the
20 rock mass is equal to the mass of rubble that has
21 fallen and apply this volumetric relationship and we
22 are able to calculate the volume of material that can
23 develop if this failure process were to progress to
24 completion.

25 Another important input to that

1 calculation is the shape of the failure zone. There
2 are several types of shapes that can occur. The
3 elliptical shape -- hello? Did somebody say
4 something? Okay. Not to us.

5 MR. HORNBERGER: One of your colleagues.

6 PARTICIPANT: Inadvertently.

7 DR. OFOEGBU: Okay. Yes. The elliptical
8 shape is used often in rock engineering because the
9 stress condition that develops at the apex of the
10 equilibrium comprehensive stress state. So that once
11 the opening has progressed to that shape, they tend to
12 equilibrate and stop the growth. So there are other
13 shapes, as we'll see later on, but using the
14 elliptical shape and using the bulking behavior of
15 rock and looking at the ranges of bulking factors from
16 1.1 to 1.5, we calculate a distribution of potential
17 highs of the failure zone, which means potential
18 amounts of loading transmitted to the engineered
19 barrier system. I need to point out that the --

20 MR. HORNBERGER: Wouldn't a bulking factor
21 of 1.1 almost require a stone mason to go in there and
22 organize those?

23 DR. OFOEGBU: Yes. It's quite low but --
24 lower values. There is a paper we looked at recently
25 that in fact did lower values, a value of 1.05, for --

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1 MR. HORNBERGER: In broken rock? In
2 broken rock? In rock like this?

3 DR. OFOEGBU: Yes. Yes. This was for a
4 coal mine, and what we speculated is that maybe
5 because of the stratified nature of the rock, maybe
6 they were looking at plug failure in most of the
7 cases. But the low values can occur. But, generally,
8 we think this field of engineering the values are
9 expected to lie in the 1.25 to 1.35 range. So when we
10 chose 1.1 to 1.5, it is to try to target an average in
11 that range. But I need to point out that the
12 lithophysal nature of the lower lithophysal rock may
13 actually, again, this is speculating, but it may lead
14 to lower values for bulking factor than the
15 nonlithophysal area.

16 Okay. DOE has looked at several ways of
17 doing this. They've done something similar to what we
18 did here. They said the shapes -- they looked at two
19 types of shapes. We think that shapes should really
20 progress to the elliptical geometry, both of them, but
21 they do represent two range -- a range of shapes that
22 one could call permissible in this kind of analysis.
23 They also plotted numbers from the numerical model
24 calculations, the volume model that I shared earlier.

25 We think that the numbers taken directly

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1 from the numerical model are smaller than the numbers
2 from the analytical model because of action. Action
3 is a process that developed because of the sheer
4 strength of rock particles. If you have a large
5 number of particles falling at the same time, they
6 tend to -- they can at times develop particle
7 arrangements that is much more open than events from
8 what you would expect from particles that have been --
9 that are deposited in thin layers or that have
10 experienced a long history.

11 But the thing is that action is an
12 attestable state. It's an equilibrium state that
13 depends on transient variables, one of them being the
14 stress on the contact of the particles, and also the
15 strength of the -- the potential for particles to
16 share against each other. So that over time because
17 of creep of particle contacts and because of ground
18 vibration, the action would disappear and eventually
19 the look at any point in the granular mass would
20 approach the steady state value which is a product of
21 the unit width and height of the -- the column height
22 of the material.

23 Now, having said that, one has to
24 acknowledge that action can occur, but you have to
25 look at it -- it needs to be looked at as the

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1 relationship between the steady state value, the
2 constant load, and slowly decreasing -- slowing
3 increasing value because of decreasing action. So if
4 somebody wants to take advantage of action to reduce
5 the load in a granular mass, it becomes necessary to
6 describe -- to characterize the transient nature of
7 the action so that ultimately the loading approaches
8 the steady state value. We think it's easier to just
9 use the steady state value, but if one can come up
10 with a function that describes the transient nature of
11 action, consider the effects of creep on particles,
12 effect of seismic potential and ground vibration from
13 seismicity, then such a transient cover would
14 definitely be one of the things that can be looked at.

15 The changing geometry of openings is an
16 area we have a lot of interest because of potential
17 effect on performance assessment. The effect on the
18 loading, mechanical loading of the engineered barriers
19 will be discussed in the next staff but we noticed
20 that the people that calculate heat flow and moisture
21 flow in the repository environment tend to use only
22 this geometry that we believe will only occur during
23 the pre-closure period. During the post-closure, the
24 openings are going to transition. They're expected to
25 transition from this geometry to that geometry, and we

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1 believe that that transition will take relatively
2 short time. I will get a slide on that. So that the
3 people that do performance assessment calculations
4 need to ensure that the models they use take into
5 consideration this change in geometry of the
6 emplacement drifts.

7 It is expected that the changing geometry,
8 that the accumulation of rock will occur within a few
9 hundred years after the openings have been abandoned,
10 that's after cessation of drift maintenance. And this
11 is an order of my estimate. It's not built on model
12 calculation, it's built on interpretation of available
13 empirical data. It's believed that the ground support
14 that is -- any ground support left in the openings
15 will degrade and within a few tens of years will lose
16 its effectiveness and will no longer be able to
17 prevent fall of blocks from the roof area. And the
18 information we presented earlier suggests that there
19 will be additional tens of years for the openings to
20 transition from the initial geometry to the
21 anticipated long-term geometry. And in order of
22 magnitude calculation such as this, we consider two
23 stacks of tens of years that will lead you to a
24 collapse time of approximately a few hundred years.

25 There is effort being made at DOE to

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1 improve this calculation approach and that effort is
2 sort of described briefly here. And what DOE intends
3 to do is to do a static fatigue testing on rocks, rock
4 samples from Yucca Mountain and try to use that
5 information to somehow calculate the rate of drift
6 degradation. Static fatigue has been -- rocks have
7 been subjected to this kind of testing for a long
8 time. What it is is you take -- in the standard
9 compression testing of rocks, a rock is taken and the
10 load is applied rapidly, and within a matter of a few
11 seconds to a few minutes the rock fails. The standard
12 of strength value obtained.

13 The value of rock strength obtained under
14 this rapid loading condition is often not appropriate
15 for calculating the behavior of rock underground
16 openings instituted. A very good example of this was
17 the Atomic Energy of Canada mined by experiment. They
18 completed an opening, I think, about 420 meters below
19 the plant surface in the underground research
20 laboratory, and we did a few months notch at the
21 opening, at the roof, roof failure. And several
22 attempts were made to try to rebuke this notch using
23 the continuum base models and the rock strengths
24 derived from the conventional laboratory test where a
25 rock is loaded and failed within a few seconds or

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1 minutes. And the experience was that we could not; in
2 fact, that was my first exposure to static fatigue
3 test.

4 We found that there was this work done by
5 a group of people at the University of Winnipeg that
6 indicated that if the rock is loaded slowly over an
7 order of this kind of time scale, ranging from maybe
8 one day to about ten days, that the strength of them
9 would be between 60 and 70 percent of the strength
10 that was obtained in the rapid loading condition. And
11 by using this reduced strength, we could get results
12 that somewhat resembled the observed notch. And later
13 on a group of people at ITOSCA did analysis with a
14 micromechanics model and this is the simulated
15 behavior, static behavior is this here. And using
16 that they were able to predict the notch that occurred
17 in a few months. In fact, it was developed within two
18 months of the construction of the opening.

19 Now, what we need to see here is that the
20 order of seconds information was found inappropriate
21 for calculating an order of one's behavior. And we
22 needed an order of this information to predict a
23 matter of months behavior accurately enough. So this
24 raises a concern about using the static fatigue test,
25 which is order of days information, to try to predict

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1 behavior that may be developed within an order of
2 maybe hundreds of years or even thousands of years.
3 The question we asked in there is whether the time
4 scale of the test is applicable to the time scale of
5 the calculation, and this question needs to be
6 addressed in order to apply the static fatigue test in
7 order to rely on drift degradation estimates that were
8 calculated based on the static fatigue model.

9 And there are several ways that this can
10 be approached. Maybe use -- apply the same model to
11 existing critical cases where openings are known to
12 have histories extending over tens of years like the
13 example I showed in the coal mines. There are also
14 openings at the Nevada test site that probably have
15 the same time scale type of history. So somehow that
16 combines this empirical information and maybe
17 combining the modeling it might be possible to develop
18 the information that can be used to address the scale
19 effect, the time scale difference between the static
20 fatigue test and the calculation time scale.

21 Well, to conclude, I need to point out
22 that there are areas where NRC staff views are very
23 similar to the DOE views in dynamic rock-block impact
24 on drip shield. I think there seems to be a common
25 understanding that this is not a concern in the lower

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1 lithophysal area. It is a concern in the middle
2 nonlith area but the concern has a number of important
3 mitigations. We believe that there is a common
4 understanding that drifts will be expected to degrade
5 and rubble will accumulate within the drifts within
6 the 10,000-year period of regulatory concern.

7 Where there are differences is, first of
8 all, regarding the amount of the static load from
9 accumulated rubble. Really, the difference here is
10 that the DOE hasn't said what it intends to do. They
11 presented a range of different ways of looking at the
12 problem, and, as I described earlier, we're kind of
13 saying don't use -- we don't believe that using the
14 information from the -- numerical information from the
15 volume model would be an appropriate way to go because
16 those have one big drawback is the action, unless
17 somehow the characterization of the action -- time
18 effects of action is included in the analysis and the
19 appropriate technical basis provided for such
20 characterization.

21 Now, on time of degradation I've already
22 discussed. DOE intends to use a static fatigue test,
23 and we believe that's a step in the right direction,
24 but there are concerns that need to be addressed in
25 using that approach. Then representation of drift

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1 degradation in the performance assessment, good. The
2 site recommendation analysis did not include drift
3 degradation. We've looked at DOE's nominal scenario
4 in the TSPA-LA Methods and Approach document and the
5 suggestion there again is that drift degradation is
6 not included, but we are still discussing this. Thank
7 you very much.

8 MR. HORNBERGER: Thank you, Goodluck.
9 Questions from the Committee? Mike? John?

10 CHAIRMAN GARRICK: Has there been any
11 back-of-the-envelope calculations or any type of
12 analysis done that would indicate the effect on
13 overall performance of increased drift degradation?

14 DR. OFOEGBU: Back of the envelope, no.
15 People have speculated on things. There are a number
16 of effects. One is on mechanical behavior of the
17 engineered barrier system. How would the drip shield
18 and waste package respond to that loading, and our
19 group is going to discuss that in the next
20 presentation. There is also a calculation on heat
21 flow that shows with the accumulated rubble accounted
22 for the temperature of the waste package will be
23 higher than predicted. And this is from calculations
24 done at the Center as well as an interpretation of
25 backfill case calculations that DOE did a few years

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1 ago. So that has been done, but that increase in
2 temperature, the implication of that on behavior of
3 the engineered barrier system and behavior of the near
4 -- space of near field has not been evaluated.

5 Then another area is seepage. In the
6 seepage calculation, there is this assumption of
7 calculated around the opening and that's predicated on
8 the existence of an opening that we believe would not
9 be there within a short time after closure of the
10 repository. So we think that that needs to be
11 modified and its effect on the calculation examined.
12 Back of the envelope, it's not easy to do for this
13 kind of thing.

14 CHAIRMAN GARRICK: Big envelope.

15 (Laughter.)

16 DR. OFOEGBU: Yes. Okay.

17 CHAIRMAN GARRICK: The other question is
18 when you survey existing unsupported openings, what
19 does the survey consist of? Is there monitoring
20 equipment, degradation transducers of some sort or is
21 it just an observation?

22 DR. OFOEGBU: Well, for openings that are
23 currently used, there is usually monitoring equipment,
24 but those openings also are usually supported. I mean
25 they have ground support on them so they are not

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1 exactly applicable, but the information there can be
2 used. But for openings that have been abandoned, no.
3 In rare cases there might be, but usually there is not
4 monitoring equipment. It's just going into observe.

5 CHAIRMAN GARRICK: Is it possible to
6 monitor something like this in terms of how close you
7 are to really having a rock falling situation?

8 DR. OFOEGBU: It is possible, and we
9 believe that this is one of the approaches that DOE
10 may use for the pre-closure period. For post-closure,
11 because the time is so long, I don't know if --

12 CHAIRMAN GARRICK: Yes. Okay. Thank you.

13 DR. OFOEGBU: Thank you.

14 MR. HORNBERGER: Ruth?

15 MS. WEINER: This is a question asked out
16 of complete ignorance of this entire process. When
17 the rocks -- when the drifts degrade and the rocks
18 fall, how much dust do you get? What percentage or
19 what by some measure do you get dust, very fine
20 particles accumulating in the interstices?

21 DR. OFOEGBU: There is dust. There is
22 usually dust. I can't say how much. I don't know
23 what the particle distribution would be, but there
24 will be a certain amount of dust.

25 MR. HORNBERGER: Other questions? Staff?

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1 Neil?

2 MR. COLEMAN: Neil Coleman, ACNW staff.
3 I've had a chance to see or to enter tunnels at the
4 site that have been isolated for a period of time, for
5 many months, six to nine months, and something I
6 noticed going in you do see debris that has fallen
7 down, and what I saw ranged from sand size particles
8 up to maybe a few centimeters. Over say 100 meters of
9 tunnel it might add up to a kilo or two of material.
10 But I don't know if this is a rate that's continuous,
11 but I guess it tends to support the idea of -- this
12 area is very well supported by steel sets and rock
13 bolts. This is the ERCB east-west drift.

14 DR. OFOEGBU: Yes. For supported
15 openings, the behavior will be different. For
16 unsupported openings, you may see a similar behavior
17 but what we need to point out is that these openings
18 have a very short history so far, and often people see
19 something and say, "Oh, that's a minor rock fall," but
20 that is the beginning of rock fall. If it stops
21 there, yes, it's minor, but if it progresses, as it's
22 expected to be, then it's really the beginning of what
23 may be much more important.

24 MR. HORNBERGER: Okay. Thanks very much,
25 Goodluck, and I guess we'll go on to our next

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1 presentation on MECHFAIL. And, Doug, you going to do
2 that?

3 DR. GUTE: Okay. Can you hear me? Okay.
4 And I'll do my best to stick to the 30 minutes as best
5 I can. As Goodluck just presented, he spent a lot of
6 time going over the basis for the rockfall loads that
7 we're assessing within the MECHFAIL module. Here
8 we're going to get a little better of an -- better
9 idea of the overview of what MECHFAIL does because we
10 do assess other mechanical types of loads other than
11 rock fall, in particular seismicity and some other
12 issues that come into play when we want to assess the
13 potential effects of mechanical damage on the
14 engineered barrier system.

15 The presentation, I'm going to try to go
16 quickly over the objective of MECHFAIL module, and
17 overview of the EBS components that we're concerned
18 about, some risk insights that have been done, and
19 this kind of goes to your back-of-the-envelope
20 calculation question earlier about how bad can it
21 potentially be, then an overview of how we implement
22 the MECHFAIL module, a characterization of mechanical
23 loads, and Dr. Ofoegbu already discussed the static and
24 dynamic rockfall characterization aspects of the talk,
25 so I'm just going to focus on seismicity in a very

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1 short way. Drip shield response to the mechanical
2 loads. I want to point out and emphasize that the
3 drip shield we have evaluated, or that has been
4 evaluated, was released by the DOE in 1999. Since
5 that time, we have had several discussions and
6 technical exchanges in Appendix 70 and were able to
7 convey that there were certain things that were
8 overlooked in their original design analysis and
9 assessment. They've gone back and looked at it, and
10 they are in the process of reevaluating, reinforcing
11 their designs or trying to take appropriate measures
12 to improve the performance of the engineered barrier
13 system components. We'll also look quickly at the
14 waste package response to mechanical loads. We don't
15 have a whole lot of detailed information here. It's
16 more of where we're going in our analysis process at
17 this time. And we'll have some closing observations.

18 The objective of the MECHFAIL module,
19 though, is to approximate the temporal and spatial
20 variations of the mechanical loads, in particular
21 seismic and rockfall loading conditions. We want to
22 assess accumulated damage because up to this point,
23 historically, people have only focused on those one-
24 time scenarios, what could potentially breach the drip
25 shield and/or waste package as a one-time event? What

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1 happens when I have much higher frequency events that
2 contribute a little bit of damage to the EBS system as
3 you go along and as time progresses has enough of
4 these higher probability events occurred to the point
5 where I do ultimately still end up reaching the drip
6 shield and/or waste package? So it has to do with the
7 aspect of assessing the effect of accumulated damage
8 on the system, and then try to identify the risk
9 significant failure mechanisms that we should focus
10 our review on.

11 The engineered barrier system components
12 are the waste package, the drip shield, invert to the
13 waste package pallet support. Some people say that
14 the nuclear fuel cladding is not being taken credit
15 for as an engineered barrier. It depends on which
16 particular document you might be reading and how old
17 it might be, but I've included in the list anyway
18 because it does have an effect on the release of
19 radionuclides, ultimately. And some people would
20 argue because of the capillary diversion credit given
21 to the drift, that the drift itself is also an
22 engineered barrier.

23 From a risk insight perspective, we want
24 to get kind of a sense of how bad it can be, your
25 back-of-the-envelope calculation that you mentioned

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1 earlier. What they found is that if we take the drip
2 shield or if the drip shield is taken out of the
3 system, that the expected dose is only increased by
4 roughly 75 percent. It doesn't seem to have a
5 significant effect on overall repository performance,
6 and that's taking the drip shield out of the system at
7 the time of closure.

8 Okay. But the TPA code currently does not
9 have the ability to assess the waste package response
10 to direct rockfall loads at the present time, and we
11 also don't consider the increased temperatures and
12 potential seepage that may enter the drift as a result
13 of the drift degradation processes. So what was
14 looked at next was to take out both the drip shield
15 and the waste package closure and see what effect it
16 would have on the overall dose, and it was shown that
17 the dose increases by approximately two orders of
18 magnitude relative to the nominal scenario. But in
19 both cases, the potential seepage and increased
20 temperatures was not considered in the TPA analysis.

21 To assess mechanical failure in the TPA
22 code, several things need to be assessed: The number
23 of seismic events that could occur over the regulatory
24 period, the temporal and spatial distributions of
25 rockfall loads, both static and dynamic, the

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1 mechanical effects of these loads on the engineered
2 barrier system, including potential interactions
3 between them, and the applicable failure mechanisms
4 and their respective failure criteria. Analyses have
5 shown that the drip shield is prone to buckling, or
6 the older design of the drip shield is prone to
7 buckling. Also, do we need to look at fracture
8 mechanics failure approach as opposed to the standard
9 continuum mechanics failure criteria or methodology?
10 That oftentimes is load- and material-dependent.

11 And also creep. It turns out that creep
12 at elevated temperatures -- even though the indirect
13 temperatures I think with in place backfill the
14 maximum expected is around 350 degrees C, which may
15 not seem to be that high of a temperature when you
16 consider metals in typical applications, especially
17 boiler pressure vessel type of applications. Turns
18 out that titanium is highly susceptible to creep at
19 relatively low temperatures, and for the titanium
20 alloys that are being used in the construction of a
21 drip shield the mechanical strength is also degraded
22 quite significantly even at temperatures of 100
23 degrees C, let alone 330 degrees C, and I'll expand on
24 that here in a little bit.

25 What has been already screened out from

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1 the MECHFAIL module has been faulting as a potential
2 significant mechanical loading condition or scenario.
3 A lot of work's been done in this area. It's not
4 expected to cause significant drip shield and waste
5 package damage. The DOE is already committed to the
6 fault-setback distance. If there are faults that they
7 encounter during the boring of the drifts and so on
8 and so forth and they know where faults are at, they
9 will make sure that the drip shields and waste
10 packages are a certain amount of distance away from
11 there so as not to be directly affected by those
12 faults. And when you go through and do a detailed
13 analysis, you find that a very small percentage of
14 drip shields and waste packages could potentially be
15 affected by this type of mechanical loading mechanism.

16 Igneous intrusion, which is also under the
17 mechanical disruption of engineered barriers ISI,
18 which is really what we're trying to encompass within
19 the MECHFAIL module, igneous intrusion also falls
20 under that umbrella, but we have left that to the
21 volcanologists to deal with in their own code modules
22 and we're not going to go there.

23 One of the things I need to point out in
24 the abstractions that have been developed for the
25 MECHFAIL module we have not considered any of the

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1 material degradation or corrosion processes that could
2 affect, ultimately affect, the structural performance
3 capabilities of the engineered component system. For
4 example, stress corrosion cracking can come into play,
5 fabrication flaws and so on and so forth. I've got
6 them listed here. We're working closely with the CLST
7 people to try to incorporate these effects into the
8 MECHFAIL module if we find that they are in fact risk
9 significant. There's a lot of uncertainty still
10 associated with whether there's appropriate
11 environment to support stress corrosion cracking of
12 the Alloy-22 material. We don't expect general or
13 uniform corrosion to be an issue with regard to the
14 waste package Alloy-22 outer barrier. However, a
15 localized corrosion is still a concern, particularly
16 in the areas of the weld seams in fabricating the
17 waste package.

18 Going on from there, strain rate effects
19 have also not been considered. Typically, high strain
20 rates which could occur when I have a dynamic impact
21 from a rock block that's falling from the ceiling or
22 during a seismic event where things are being shaken
23 quite rapidly, those high strain rates that the
24 materials may experience typically illustrate or
25 causes the material to have a much higher yield

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1 stress, but then again it reduces the ductility of the
2 material. In other words, you can't stretch it as far
3 out as you would like to or what it would under very
4 slow applied loads until it fails.

5 To accommodate the accumulation of damage
6 within the MECHFAIL module we found the most expedient
7 way of doing that was to sum up the plastic strains
8 associated with the event that might occur from one
9 time step to the next. Typically, plastic strains
10 dominate in magnitude the total strains that a
11 material will incur. The elastic recovery or the
12 elastic part of the strain is relatively small, even
13 for very large stress fluctuations. And we found
14 this, like I said, to be the most expedient way to try
15 to accommodate the accumulation of damage or assessing
16 the accumulation of damage from one disruptive event
17 to the next.

18 Temperature effects. What I've got
19 plotted here is some recent information developed by
20 our TEF folks. The waste package temperature with
21 emplaced backfill, as you can see, can be quite high
22 right after closure, approximately 350 degrees C.
23 That emplaced backfill is going in and taking crushed
24 tuft or some other aggregate and placing it around the
25 drip shield and waste package and filling it up as

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1 high as you possibly can to the top of the drift. An
2 added benefit of doing that is that you end up
3 decreasing the void space that the rock can fall into,
4 and you end up building extra support for the drift
5 ceiling and you don't develop these large, relatively
6 large static rockfall loads or you don't have dynamic
7 rockfall any longer. It supports the drift. But they
8 have to deal with the elevated temperatures that go
9 with it for several hundred years. But, ultimately,
10 within the first thousand years you get down to
11 temperatures that you would expect if you had just had
12 an open drift anyway.

13 Now, with natural drift degradation using
14 the degradation rates used within the MECHFAIL module,
15 the waste package surface temperatures were estimated,
16 and that's identified by the green curve here. The
17 temperatures aren't nearly as high as they would be
18 for the emplaced backfill case but still rather high,
19 much higher than the 150 degree C range that has been
20 typically considered to be a maximum value, if you
21 will. And it turns out to be still quite significant
22 from a mechanical property standpoint, and I'll show
23 you that on the next slide. For all of our analyses
24 this plot was generated after we had done a great deal
25 of our work, and we were using the ultimate drip

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1 temperatures for our mechanical properties, and that
2 was assumed to be 150 degrees C.

3 What I wanted to quickly show here is that
4 a lot of people don't recognize or realize that these
5 temperatures can have a significant effect on the
6 mechanical properties of the EBS components,
7 particularly with regard to titanium grade 7, which is
8 the plating material for the drip shield. These are
9 normalized yield strength values on the left. Yield
10 strength is at the point when the material no longer
11 behaves in a linear fashion. Once you exceed that
12 stress it plastically deform and it won't spring back
13 to its original shape. And these are normalized with
14 respect to their room temperature values, all right?
15 At approximately 150 degrees C, the titanium grade 7
16 plate its yield strength has been reduced by 30 to 35
17 percent relative to room temperature. This was not
18 considered in the original deal reassessment of their
19 drip shield design, and this is, in my opinion, one of
20 the major oversights in that initial design process.

21 After we get up to the natural backfill
22 condition, the maximum temperature being around 250
23 degrees C, it's reduced by roughly 60 to 65 percent,
24 but once again the rockfall loads haven't necessarily
25 fully manifested themselves at that point either.

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1 Then we have similar behavior for the other materials.
2 Also, I want to point out that the ultimate tensile
3 strength is also significantly reduced. The ultimate
4 tensile strength is the point at which it can no
5 longer carry any more stress and for all intents and
6 purposes it's been breached at that point.

7 One of the things I want to point out,
8 though, is that this can be overused in the sense that
9 just because you get to that stress level or you make
10 some approximations that you're approaching the
11 ultimate stress, you don't want to necessarily say
12 that you've breached the system. It turns out that
13 Alloy-22 is very, very ductile material, and you have
14 to get roughly 60 percent strained before you get to
15 failure. So when we start approaching stresses of
16 this magnitude, we recognize we're going to undergo a
17 lot of plastic deformation, the contact between maybe
18 the drip shield and the waste package in the contact
19 area may increase significantly.

20 By the contact area increasing, we're
21 reducing the overall average stress, and therefore you
22 may not ultimately end up breaching material. You
23 want to take advantage of the ductility of that
24 material. That's why we're trying to base the
25 accumulation of damage on plastic strains, the

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1 accumulation of plastic strains, because you want to
2 take advantage of what the material gives you, and it
3 would be premature just to do an easy stress analysis
4 and say, "I've breached it," because that's not the
5 case, because you've got all this plastic deformation
6 or ductility available in the material.

7 Characterization of seismic loads, I'll
8 just go over this very quickly. It's based upon --
9 the TPA code uses the seismic hazard curve data
10 developed for a rock outcrop on the surface. It's
11 characterized in terms of the mean peak horizontal
12 ground acceleration within the TPA code. That's the
13 only parameter at the present time we have to work
14 with in assessing what kind of damage may be incurred
15 by the EBS system under seismic conditions. There
16 isn't enough data at this point to determine whether
17 that's sufficient to make a fair assessment of the EBS
18 under seismic conditions. That work is still
19 underway, so I'm not sure if this is going to be
20 ultimately sufficient or if we're going to need more
21 information in the long run or not.

22 And I'm sure you guys have heard about
23 this before and are well familiar with the low
24 frequency or low probability of occurrence
25 earthquakes, what their magnitude should be or won't

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1 be, whether they should be capped or not, so there's
2 a lot of variation and potential variation of what
3 could happen here. Whether those are risk-significant
4 loads or not I'll leave to the PA folks to explain in
5 the future. Apparently, if I assume that a ten to the
6 minus six event fails all the drip shields and waste
7 packages and the releases are simply through the
8 ground surface, when you combine that dose with that
9 probability it's not really risk significant. But
10 what we're concerned about here from a seismic
11 standpoint is can I accumulate damage from the much
12 higher frequency earthquakes such that at the end of
13 a couple thousand years have there been enough of
14 these events to ultimately end up causing breaching to
15 occur anyway? I don't want to focus just on one event
16 causes failure and if it doesn't, then I forget about
17 it. I need to know what the highest seismic load can
18 be -- or, actually, let me turn that around, what the
19 lowest seismic load is that would cause potential
20 damage to the waste package. We need to start
21 accumulating that damage. Is it a ten to the minus
22 three earthquake, is it a ten to the minus four, ten
23 to the minus five earthquake before I start seeing
24 appreciable damage on the system?

25 Right now we feel like the TPA sampling

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1 methodology is a good way or a good approach for
2 dealing with the high frequency -- high probability
3 seismic events, but if we get into the lower
4 probability events, we probably have to look at it as
5 scenarios, unique scenarios.

6 For the response to the drip shield of
7 seismic loads, we haven't performed any detailed
8 seismic ground motion time history analysis as of yet.
9 We're in the process of doing that. Before we develop
10 the models for this type of analysis, we're performing
11 Eigenvalue analyses to get a sense of where the
12 natural frequencies of the system are. Natural
13 frequencies are a strong part of how systems behave
14 under seismic loads. Will the natural frequencies of
15 the system be excited or not? Is the potential for
16 dynamic amplification of the response there? One of
17 the other questions that has yet to be answered is
18 what effect will these accumulated masses or rockfall
19 loads on the system have? Will the rock mass move in
20 phase with the drip shield? Will it respond as one?
21 Will they counteract each other, and we will
22 ultimately have kind of a mass vamping scenario?
23 There's a lot of uncertainty here.

24 The analysis that have been done to date
25 indicate that the drip shield has several natural

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1 frequencies below this 33 hertz threshold. The 33
2 hertz threshold is important because that's where the
3 vast majority of the energy associated with the
4 seismic event lies within that frequency spectrum. It
5 depends on whether it's a freestanding drip shield,
6 whether they bolt it to the invert floor or weld it to
7 the invert floor. All these things can have an effect
8 on how the system will behave under seismic
9 conditions.

10 Moving on to static rockfall loads, here's
11 our process level model. It was recognized very early
12 that when I had drift degradation the rubble
13 accumulating on the sides of the drip shield will
14 provide some structural support, and we felt it was
15 very inappropriate not to take some consideration for
16 that structure support in assessing the capabilities
17 of the drip shield and how it will respond under these
18 static low conditions. We've modeled it as a
19 continuum. Now, how much stiffness is associated with
20 that rock rubble is a very difficult thing to get a
21 handle on. There's a lot of variability potentially
22 there, so what we did was a sensitivity analysis
23 varying the Young's modulus of that rock mass on the
24 side of the drip shield to get a sense of how it could
25 affect the overall response of the static loads.

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1 MR. HORNBERGER: What's the basis for the
2 depth distribution there on the previous slide?

3 DR. GUTE: You mean as far as --

4 MR. HORNBERGER: Yes.

5 DR. GUTE: -- from the depth?

6 MR. HORNBERGER: Your blue curve.

7 DR. GUTE: Oh, the blue here?

8 MR. HORNBERGER: Yes.

9 DR. GUTE: This is the boundary of the
10 drift, of the drift wall. And it goes up in the --

11 MR. HORNBERGER: So that's not a pressure
12 distribution on the curve.

13 DR. GUTE: No, no. Actually, this is
14 displacement constraint. This is an interface where
15 we're allowing this to slide along the drift wall, the
16 original drift wall. And everything above this point
17 is degraded above it. And then we've got the
18 overburden pressure assigned on the top surface here
19 and also the appropriate pressure over the crown of
20 the drip shield as well.

21 MR. HORNBERGER: Okay.

22 DR. GUTE: The results indicated that the
23 buckling load of the drip shield is really sensitive
24 to the Young's modulus that was assigned to the rock
25 mass on the side. Based on this information, along

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1 with some insight into the deficiencies of our process
2 level model, we've taken advantage of symmetry,
3 boundary conditions, loading conditions, not
4 necessarily the elevated the temperature to the 250
5 degree C that we saw earlier. There's a number of
6 things that come into play. Putting all the
7 information together, like Goodluck talked earlier,
8 you just can't look at one piece of the analysis and
9 come to a conclusion. Putting all of our knowledge
10 together we developed a distribution for the
11 appropriate buckling load of the drip shields that
12 would be assigned throughout from within the MECHFAIL
13 module.

14 I neglected to point out earlier and I
15 need to resolve that now is we account for spatial
16 distributions or variations within the MECHFAIL code
17 by breaking each of the TPA code subareas into two
18 spatial grids. One spatial grid represents the lower
19 lithophysal rock, the other spatial grid represents
20 the middle nonlithophysal, because there are unique
21 properties associated with both. The important ones
22 are the bulking factor. For example, the bulking
23 factor for the lower lithophysal could be potentially
24 much smaller than for the middle nonlithophysal, so we
25 have different ranges there. Am I running out of

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1 time? Okay.

2 What else? There's a few other parameters
3 that we do vary spatially, so that is accounted for in
4 the MECHFAIL module. So we're accounting for both the
5 spatial and temporal variations in the number of our
6 key parameters.

7 Okay. One last note here: During a
8 seismic event, the effective loads of the accumulated
9 rockfall is also increased to account for the seismic
10 conditions. Right now we have no idea if there's any
11 potential dynamic amplification within the rock
12 itself, how does it respond to seismic loads, those
13 types of things? But right now we're just treating it
14 as dead weight, rigid body that is increased by
15 whatever the PGA of that particular seismic event
16 might be.

17 Drip shield response to dynamic rockfall
18 loads, here's a quick overview of the model. One of
19 the important things to note here is that our rock
20 block has an infinite strength and a response and a
21 purely elastic matter. Now, everybody recognizes that
22 when the rock block impacts the drip shield it's
23 likely to fracture in places. It's hard to say
24 whether it will be highly localized or whether it will
25 be a general fracturing of the rock block, but there

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1 was kind of an understanding between us and DOE where
2 we did not want to spend all of our resources and time
3 trying to figure out how much of the energy associated
4 with the rock block is taken up by the rock block
5 fracturing, because really what is the important thing
6 on our mind is how well is the drip shield going to
7 perform under these conditions? So we've taken the
8 approach that the rock block should be modeled as --
9 well, I shouldn't say should but it's acceptable to
10 model it as a purely elastic body and not get too hung
11 up on its fracturing and how much energy is being
12 dissipated. Because as it ultimately was shown to be
13 that this is not a highly risk-significant mechanical
14 loading scenario.

15 And Goodluck mentioned this earlier, a
16 couple of the assumptions in the MECHFAIL module is
17 that once a half meter of rubble is built above of the
18 drip shield crown, the effect of that dynamic rock
19 block coming down and hitting the drip shield is
20 pretty much mitigated, and so we don't worry about its
21 effect on the drip shield per se, hitting it directly.
22 We do, though, consider the accumulation of that
23 rockfall into the static rockfall loads. That is
24 accounted for. Also, dynamic rock block loads have
25 been assumed to only occur during seismic events. The

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1 accumulated rockfall loads are characterized in terms
2 of the time degradation rate that's been assigned to
3 that particular spatial grid element, and it's
4 controlled by its bulking factor and some other
5 parameters. But dynamic rockfall only occurs during
6 a seismic event.

7 Here's an example of the analyses that
8 were conducted at the Center illustrating the response
9 of the drip shield to a two-ton per meter rock block.
10 The stresses turn out to be exceptionally high here in
11 the transition area between the side and the crown, in
12 this area here, and also up in the reinforcing
13 bulkhead and the transition between the plate and the
14 supporting bulkhead here. Another item to point is
15 because it has been assumed that the dynamic rock
16 blocks only occur during seismic events, that the
17 invert is also moving upward at a constant one meter
18 per second over the duration of the analysis.

19 From this information, we ran a number of
20 these, we were able to abstract or characterize drip
21 shield displacement, velocity, equivalent plastic
22 strains, Von Mises Stress and a number of things in
23 terms of rock block mass and its fall height.

24 Waste package response to seismic and
25 rockfall loads, not a whole lot of work has been

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1 completed in this area. We've been working on this
2 quite vigorously for the last year or so. Once again,
3 the response to seismic ground motion time histories
4 has not been assessed. We're currently in the middle
5 of an Eigenvalue analysis to determine what the
6 natural frequencies of the individual components in
7 the overall system are. We have not conducted any
8 analyses to assess the response of the waste package
9 to direct rockfall loads. DOE is committed to
10 protecting the waste package from those rockfall loads
11 by way of the drip shield.

12 One of the things that could potentially
13 be an issue here, and let me see if I've got this on
14 the next slide, has to do with drip shield and waste
15 package interactions. What happens when the drip
16 shield buckles is that it transfers that load to the
17 waste package, and the design that we're evaluating
18 has these roughly four centimeter thick bulkheads
19 underneath the crown of the drip shield and based upon
20 our estimates of the rockfall loads, which is anywhere
21 from 40 to 160 tons per meter length of drift, that
22 load is all being focused on a per meter length
23 because these bulkheads are separated by approximately
24 one meter. All that load is being transmitted to the
25 waste package through that bulkhead that's only four

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1 centimeters wide. There's no guarantee also that that
2 bulkhead will be resting flat on the waste package.
3 Chances are it's going to be skewed a little bit and
4 the edge of that particular beam could be eating or
5 digging into the waste package.

6 And we're conducting analysis now to find
7 out how much plastic deformation must be incurred by
8 the waste package before it can reach equilibrium to
9 support those loads above it that are being
10 transferred to it. Ultimately, the drip shield may be
11 shown to not buckle at all once they come in with
12 their revised design, but that design is not available
13 to us now for reevaluation and consideration in the
14 current abstractions we have in the MECHFAIL module.

15 That's under static conditions. The issue
16 also becomes exacerbated under seismic conditions.
17 Let's say I've got this large static rockfall load,
18 the bulkhead's digging into the waste package surface,
19 I've reached some equilibrium point, I'm okay, but now
20 a seismic event comes along. What's it going to take
21 now to cause more plastic straining of the waste
22 package to get me to failure? And those are all
23 questions that have yet to be answered, and hopefully
24 we'll be getting those answers here in the next six
25 months or so.

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1 Let's see, MECHFAIL module outputs are the
2 modules. We provide the percentage of drip shield
3 failures. And by failure there's two aspects of
4 failure when we're talking about the drip shield here.
5 One is continuing to protect the waste package from
6 rockfall loads, and the other is has it been breached?
7 Now, right now if it does buckle, there are localized
8 plastic strains that occur as a result of the large
9 displacements associated with the buckling that also
10 causes local breaching to occur. The size and extent
11 of those breaches is very difficult to quantify, but
12 we do have a pretty good idea of where the general
13 area of those are, but quantifying the sizes is a
14 difficult thing to do.

15 Percentage of waste package failure on
16 subarea time step basis, and here's another area I
17 need to emphasize. Right now the MECHFAIL module does
18 not predict any performance parameters of the waste
19 package at all. We don't have the abstractions in
20 place. Although we have the place holders in the
21 MECHFAIL module code to insert the abstractions and
22 the logic and everything is there, the specific
23 abstractions necessary to assess what potential waste
24 package failure has yet to be implemented within the
25 MECHFAIL module. All we can predict right now is we

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1 have a pretty good handle on -- and I shouldn't say
2 predict -- but estimate the potential drip shield
3 response to these mechanical loads. Okay?

4 Preliminary results indicate that on
5 average 75 percent of the drip shields buckle under
6 static rockfall loads within 500 years after closure.
7 Degradation of the invert may increase drip shield
8 interactions with the waste package. Up to now many
9 of these models have simply assumed that the invert
10 remains intact. However, the invert is made of carbon
11 steel structural framework. That carbon steel is
12 going to corrode very quickly after closure, if not --
13 actually, this is kind of an issue during the pre-
14 closure timeframe as well because carbon steel
15 apparently corrodes very quickly in the presence of
16 nitrate, and from what I understand, the nitrates are
17 being taken credit for as being a corrosion inhibitor
18 for the Alloy-22. So it's either one or the other.
19 But, anyway, the carbon steel is expected to corrode
20 rather quickly. The aggregate, which may be highly
21 compacted or whatever, that exists between the
22 structural framework of the invert could have a very
23 high compressive strength but then again it probably
24 doesn't have much of a tensile or sheer strength
25 unless they provide some type of cement material to

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1 enhance its mechanical properties or behavior. But
2 that invert could degrade quite quickly, and how good
3 is that -- of a support does it provide the engineered
4 barrier system, and do we end up with -- the drip
5 shield legs or feet is a very small surface area, and
6 with the rockfall accumulating above it, it could
7 settle into the drift in very odd orientations. And
8 the same with the waste package.

9 Let's see, it's not clear to us that when
10 DOE does come out with the update design that we were
11 going to have to go back and redo all this analysis
12 again. Conceptually, once we're all done with this
13 stuff, we may find that based on the information we
14 have that the current performance characteristics are
15 enough to say that, "Hey, this really isn't risk
16 significant." That information doesn't exist yet, but
17 ultimately we prove to ourselves, and DOE may provide
18 the information to support this, that it's not a major
19 problem. But on the other hand, if it's ultimately
20 shown that this drip shield-waste package interactions
21 does lead to a significant number of or percentage of
22 waste package failures or concerns, it's going to have
23 to be taken into consideration and evaluated, taken
24 the time to evaluate the new drip shield design in
25 more detail when it is ultimately released.

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1 And that's the end of my talk. Any
2 questions?

3 MR. HORNBERGER: Yes. Thanks, Doug. Am
4 I -- let's see if I have a main message here from what
5 I've heard in the past two talks. Is one of the main
6 points that from a risk insights perspective it is the
7 static loading and hence the calculation or
8 assumptions of rock fall and the extent of rock fall
9 and the loads produced by rock fall is probably the
10 most important thing?

11 DR. GUTE: It's what's driving the system
12 really from a mechanical failure point of view, from
13 my perspective. Those are the design basis loads or
14 the expected loads that need to be considered in
15 assessing how the EBS will behave or respond under
16 seismic conditions as well as just the static loads
17 themselves.

18 MR. HORNBERGER: Okay. Thanks. Mike?
19 John?

20 CHAIRMAN GARRICK: I just wanted to
21 comment and make it a question, and that is that in
22 your risk insight statement you said that the removal
23 of the drip shield will increase the dose some 75
24 percent. That strikes me as maybe this is a "no never
25 mind" issue given the fact that the dose calculation

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1 itself, I suspect, has an uncertainty associated with
2 it by a factor of at least ten and probably more
3 between the fifth and 95 percentile. So why are we
4 fussing around with this?

5 DR. GUTE: Well, if you take the drip
6 shield out of the system, you no longer have a rock
7 shield for the waste package.

8 CHAIRMAN GARRICK: I know.

9 DR. GUTE: Okay.

10 CHAIRMAN GARRICK: But I'm thinking about
11 the end result here. So what?

12 DR. GUTE: Well, as I said, we're --

13 CHAIRMAN GARRICK: If you remove the drip
14 shield and you only get an increase of 75 percent in
15 the dose, why do I care?

16 DR. GUTE: Well, the TPA code does not
17 consider the potential failure of the waste package
18 from those direct rockfall loads.

19 CHAIRMAN GARRICK: I'm not communicating.
20 I'm saying that I don't care if the rocks come in if
21 it doesn't affect the performance substantially, and
22 your risk insights information is telling me it
23 doesn't affect the performance.

24 DR. GUTE: No, it affects -- well, if you
25 just take out the drip shields and assume nothing

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1 happens to the waste package, your interpretation is
2 correct. However, the TPA code does not take into
3 consideration the potential failure modes of the waste
4 package that occur because the drip shield is not
5 there. We're taking credit for the drip shield being
6 --

7 CHAIRMAN GARRICK: Has that calculation
8 been done?

9 DR. GUTE: Well, that's why the second
10 part of the calculation was done to take out both the
11 drip shields and the waste packages to see as --

12 CHAIRMAN GARRICK: Yes, but how much of
13 the waste package was taken out?

14 DR. GUTE: One hundred percent.

15 CHAIRMAN GARRICK: Well, see, that's an
16 irrelevant -- that's a nonsensical assumption.

17 DR. GUTE: Yes, it is -- well, it's a
18 back-of-the-envelope calculation is what it is.

19 CHAIRMAN GARRICK: Yes, right.

20 (Laughter.)

21 DR. GUTE: Because it's convenient,
22 because we don't have enough information to make any
23 more detailed assessment at this point.

24 CHAIRMAN GARRICK: Yes. Well, I always
25 like to look at the so what question.

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1 DR. GUTE: Well, I appreciate that.
2 That's fine.

3 CHAIRMAN GARRICK: What is the consequence
4 here of rocks falling in on the waste package? Does
5 it really make that much matter given the
6 uncertainties that are involved? Given that you're
7 two orders of magnitude below the standard, given that
8 there's probably a factor of ten to 100 uncertainty
9 associated with the dose calculation, what kind of
10 impact does this really have?

11 DR. GUTE: Well, as I mentioned earlier,
12 when you take away both the drip shield and the waste
13 package, you end up increasing the dose by two orders
14 of magnitude and not --

15 CHAIRMAN GARRICK: Yes, but that isn't --
16 I'm talking about physical reality --

17 DR. GUTE: Yes.

18 CHAIRMAN GARRICK: -- and in terms of our
19 knowledge of the analysis. And our knowledge of the
20 analysis -- we should be able to calculate within a
21 certain uncertainty what the dose is as a result of
22 what we expect to actually happen, and if we're now
23 saying that what we expect to happen is that we're
24 going to fill these tunnels up with rocks in a few
25 hundred years rather than a few tens of thousands of

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1 years, that ought to be something that's very
2 calculable. That's all I'm saying.

3 DR. GUTE: Well, I appreciate what you're
4 saying, but -- yes?

5 PARTICIPANT: Tim wants to say something.

6 DR. GUTE: Oh, okay. Go ahead, Tim.
7 Thanks.

8 MR. McCARTIN: I think we agree with you,
9 Dr. Garrick. I guess one thing I would like to
10 supplement some of the things that Doug's saying.
11 Although label the risk insight, there is a part of
12 that calculation we will take out the drip shield.
13 But as he was saying, the only thing accounted for
14 there is the fact that now we have more water coming
15 in. And so that increase in dose was really due to
16 fill-up time for our bathtub model primarily, and so
17 the dose occurred a little earlier and becomes a
18 little larger. Part of the risk insight, though, is
19 also that what isn't accounted for, and that's the
20 explanation of we didn't account -- that calculation
21 doesn't account for the ability of the -- the
22 capability of the drip shield --

23 CHAIRMAN GARRICK: I guess --

24 MR. McCARTIN: -- to limit the deleterious
25 chemistries getting on the waste package. And that

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1 needs to be looked at, and so that part that, gee,
2 without the drip shield, maybe corrosion of the waste
3 package could occur sooner and there could be other
4 effects that the TPA code isn't accounting for.

5 CHAIRMAN GARRICK: Right.

6 MR. McCARTIN: So there are some other
7 aspects that go beyond just that number.

8 CHAIRMAN GARRICK: Yes. I understand.
9 Okay.

10 MR. HORNBERGER: Of course, when we talk
11 about taking out the drip shield, the understanding in
12 terms of the risk insight doesn't mean that we
13 necessarily have to consider that the drip shield has
14 been physically removed.

15 CHAIRMAN GARRICK: No.

16 MR. HORNBERGER: We just mean that some of
17 it, a portion of its capability has been compromised,
18 and I think that's the thrust of the question.

19 CHAIRMAN GARRICK: Yes. Right, right. It
20 is.

21 MR. HORNBERGER: Ruth?

22 MS. WEINER: I have two kind of unrelated
23 questions. When you talk about performance of the
24 drip shield, something interfering with performance,
25 are you talking about something in addition to just

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1 protecting the waste package from drips?

2 DR. GUTE: From the water from --

3 MS. WEINER: Yes, from water.

4 DR. GUTE: We look at it from a mechanical
5 standpoint. I view it as more of a rock shield than
6 a drip shield, because it is taking credit by the DOE
7 to protect the waste package from all rockfall loads.

8 MS. WEINER: Okay. That was one question.
9 The other thing is you have a code that calculates all
10 this stuff, you know, deformities and so on. Have you
11 ever looked at how your MECHFAIL code would calculate
12 falls and stresses in the waste isolation pilot plant,
13 for example? I mean here is a place where you've
14 really had rockfalls and you really do have impacts on
15 stuff, barrels that are sitting there. Would that
16 make a good calibration benchmark, whatever?

17 DR. GUTE: Well, what you're saying is
18 have we validated our finite element and computational
19 models.

20 MS. WEINER: Yes.

21 DR. GUTE: We have significant experience,
22 several decades of experience doing this type of
23 modeling effort. NRC has accepted over I don't know
24 how many years now these computational models for
25 assessing transportation casks, accident scenarios,

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1 the behavior of the materials are fairly well
2 understood under these types of conditions, the
3 appropriate assumptions are pretty well understood.
4 So validating these models against actual empirical
5 situations has really been done quite a bit way back
6 in the '60s and '70s at Sandia Labs, NASA and any
7 other applications, and we have a lot of confidence
8 that these are pretty good approximations of the
9 behavior of the system.

10 MS. WEINER: So you used a finite element
11 model like the kinds we used at Sandia to --

12 DR. GUTE: Or any other --

13 MS. WEINER: -- look at the deformation
14 casks.

15 DR. GUTE: Absolutely. Absolutely.

16 MS. WEINER: Thank you.

17 MR. HORNBERGER: Questions from staff?
18 Any other questions? Neil?

19 MR. COLEMAN: Neil Coleman, ACNW staff.
20 Doug, how important is seismicity in your drip shield
21 calculations?

22 DR. GUTE: Actually, little to none. What
23 happens is that the -- based on the current design and
24 the abstractions as they were developed, it turns out
25 that, as I pointed out, 75 percent of the drip

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1 shields, on average, fail or buckle within the first
2 500 years, so there's very little seismic activity in
3 that first 500 years. At the end of 1,000 years, and
4 I just talked to somebody the other day about this to
5 get a handle on where the code stands and what type of
6 behavior they're getting out of the MECHFAIL module,
7 because all we really did was develop the individual
8 abstractions and then we put it all together, and what
9 the ultimate result was we had no idea. So we wanted
10 to get -- see what the results were as to what's
11 dominating failures, what can happen.

12 From what I understand, the current output
13 from the MECHFAIL module indicates that buckling in
14 roughly 80, 85 percent of the drip shields within the
15 first 1,000 years, and the remaining 15 to 20 percent
16 experience creep failures in the titanium plate. But,
17 once again, that's under mean conditions. That's a
18 single realization under mean input value, so there's
19 not a lot of different variations as far as playing
20 around with the distributions and everything as you
21 would get from maybe doing 500 realizations. But
22 that's the information I have now, but it's not
23 dependent on seismic loads to cause that buckling to
24 occur.

25 What I saw early on when we were first

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1 developing this was after that first 1,000 years
2 because the code assumes that the -- I shouldn't say
3 assumes, but our abstractions indicate that the static
4 rockfall loads will have fully manifested themselves
5 within the first 1,000 years, at that point we've got
6 all these drip shields that buckled and within the
7 next 9,000 years you see maybe a small percentage of
8 additional buckling occurring because of the seismic
9 activity beyond that point, but it's not significant.

10 MR. HORNBERGER: Good. Thanks very much,
11 Doug. We have at least one --

12 CHAIRMAN GARRICK: We have two.

13 MR. HORNBERGER: Two.

14 CHAIRMAN GARRICK: Raj wants to make a
15 comment, and then we'll hear from Mark.

16 MR. NATARAJA: This is Raj Nataraja, NRC
17 staff. I'd like to make a couple of closing remarks,
18 basically. First, I would like to thank you for this
19 opportunity to brief you on these two topics which we
20 think are risk significant based on the information we
21 know. And it may so happen that you will be hearing
22 a lot about these things within a short time when you
23 go to Nevada. Hearing presentations might cover some
24 of these similar topics. So we thought it was
25 appropriate for you to listen to the staff views

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1 before you went for this meeting with DOE there.

2 And I don't want to say too much about the
3 PCSA. I think we are on the right track. We all
4 agree that it is son of PRA, if you want to call it.
5 But we'll have a lot more work that we'll do in the
6 coming --

7 CHAIRMAN GARRICK: SPRA, a pseudo-PRA.

8 MR. NATARAJA: Okay. And we will work
9 with more examples and more kinds of designs as the
10 information becomes available.

11 As far as the drift degradation issue is
12 concerned, as you know, it's a very complex topic and
13 we don't have any simple techniques to use to come up
14 with predictions. And DOE and NRC staff have been
15 discussing this issue for a long time, and whatever we
16 have said here is not -- no surprises here. DOE has
17 heard these before, and I'm sure Mark Board is going
18 to make some final remarks, and his observations may
19 not agree with our observations, but we also know
20 that. We have had these discussions. We will have
21 more discussions on this topic.

22 And the reason why we have done what we
23 have done is because of the fact that there were
24 assumptions made which we thought were not technically
25 supportable. Why we expect the -- there is a lot of

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1 lateral radiability within the repository horizon.
2 There might be some sections which will remain stable
3 for a long time relatively. There might be other
4 sections which might collapse relatively shortly after
5 the post-closure starts. So there's going to be a
6 whole range of conditions, and in reality things are
7 somewhere in between. They may not be totally
8 elliptic with 160 feet of rock sitting on top of -- it
9 may not be a clean opening, but all these have to be
10 factored into the performance assessment, and already
11 it is just a fear of KTI. We don't do the
12 consequences. So we are sort of forcing this issue on
13 the PA so that they look at the impacts and it's the
14 goal of DOE to show it's a "no, never mind." It may
15 be "no, never mind," but I don't think that we have
16 the information to make that conclusion and decide.
17 So that's what I wanted to just say, and hopefully
18 with this background when you go and visit the DOE you
19 will have the entire picture before you. Thank you
20 once again, and I would like to thank all the staff
21 from the Center who spent a lot of time preparing for
22 this, and we had a number of rehearsals. It's look
23 like it paid off. We are well within our time.

24 CHAIRMAN GARRICK: Well, we would like to
25 thank them too. The presentations were very

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1 interesting, and we realize the preliminary nature of
2 them.

3 MR. NATARAJA: Thank you.

4 CHAIRMAN GARRICK: All right. Mark?

5 MR. BOARD: My name is Mark Board, and I
6 am the Subsurface Project Engineer for BSC at the
7 Yucca Mountain site, and I just wanted -- well, first
8 of all, I just wanted to state a couple of things that
9 I thought were probably necessary to be stated in
10 regard to the calculations that you saw, because we do
11 see things a little bit differently. And I know
12 you're coming out in another month and we'll show you
13 our calculations and take you underground and look at
14 the rock, and perhaps we could have more discussion at
15 that point in time. So I'm not going to go into any
16 of that but I just wanted to overview perhaps where we
17 have a little bit of differences.

18 First of all, I want to thank Raj. I just
19 wanted to point out that I think we have a very good
20 working relationship and information exchange with the
21 people from the Center and from NRC. I think we've
22 had some very frank technical exchanges and
23 discussions with them, and I feel that they've been
24 very open in sharing information, so I want to thank
25 them for that.

1 And I also want to agree with Wes Patrick.
2 He said in his opening statement that we need to be
3 very careful with using empirical mining studies to
4 make extrapolations for this particular problem. And
5 I want to second that point. Most of what you saw
6 today is based on empirical calculations that are
7 extrapolations from mining studies, and you need to be
8 very careful with those studies, because they're
9 typically based on situations where the rock has been
10 subjected to very high stress levels, high extraction
11 ratios because people want to make money. It's an
12 economic situation. So they mine as much as possible
13 right to the level where the rock is going to give
14 them problems and collapse.

15 For example, the coal mining example that
16 you showed, the extraction ratios are typically very
17 high with high pillar stresses in a laterally or
18 horizontally bedded deposit which is what promotes
19 vertical piping and collapse. And in our case we've
20 got tunnels that are very widely spaced apart.
21 They're five and a half meters spaced on 85-meter
22 centers, and I don't recall that's an extraction ratio
23 certainly of less than ten percent, which means that
24 the excavations act as isolated headings that don't
25 interact with one another from a stress standpoint.

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1 And we feel that you can't simply take empirical
2 studies and extrapolate those things with our
3 situation because it just doesn't necessarily apply.

4 If you look at the current ESF and ECRB
5 excavations there that we have right now, which have
6 been open for about seven years, five to seven years
7 time, we have excavations as large as 25 feet in
8 diameter that have been mined in probably our poorest
9 quality lower lithophysal unit that don't have any
10 recorded ground falls or rockfalls at all in that
11 five- to seven-year span of time, and they're
12 monitored very closely. Plus we measure deformations
13 and those excavations have been stable from a
14 deformation standpoint since they were excavated. So
15 just keep in mind that although it's not 1,000-year
16 timeframe, we do have some examples there.

17 Just to point out that NRC's approach has
18 been on an empirical approach where they calculate
19 depth of failure and time to failure based on
20 empirical methods, and they ultimately have to lead to
21 very conservative results or on the very high end of
22 the scale. The reason being that all these things
23 like stand-up time are things that were developed for
24 the mining or tunneling industry to keep people safe,
25 almost like OSHA requirements that state that you

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1 can't send people into work under an unsupported roof
2 after it's been open for so many hours.

3 Very clearly, if you look at things like
4 stand-up time curves, you see times in hours or days
5 there that even good quality rock stands up for.
6 Well, we know that that's from a collapse standpoint
7 is ludicrous. We have many, many excavations around
8 the world that are unsupported that have very large
9 spans that have been open for hundreds of years. I
10 could take you to Sweden down in the Stora coppermine
11 where every kind of Sweden dating back to Gustavus
12 Adolphus has signed the wall of a main entry chamber
13 that's unsupported since the 1500s, and tour groups
14 are taken down there. So it's very clear that this
15 doesn't necessarily apply to all rocks. It's really
16 a tunneling contracting type of a situation.

17 We feel, from our standpoint, it's much
18 more important to try and understand the mechanics of
19 how the rock behaves and use extrapolations based on
20 an understanding of mechanics as opposed to the
21 empirical route, although we try to use that -- we've
22 been trying to use it to calibrate our models. And
23 what we've been trying to do is use parametric studies
24 to see just how sensitive the response is to
25 variations in rock properties, stress conditions and

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1 things like that. So we are using different
2 approaches.

3 I think the bottom line is I certainly
4 think we agree with the comments that Goodluck and
5 Doug made, and that's that the static weight of the
6 broken rock is the important issue. It's probably not
7 so much the seismic issue, but it's that static weight
8 of the rock that's important. We differ with them on
9 the depth that the rock fails and the load that's
10 applied to the static -- to the drip shield and the
11 timing over which that happens. We think it's going
12 to occur over a much longer period of time than what
13 they do. Now, maybe in the end result that's going to
14 be splitting hairs depending on what the TSPA model
15 says. I really don't know right now. We're just
16 trying to take it from the calculations standpoint
17 that we're at to try and show what those loads and
18 things are. I really can't tell you, I don't really
19 know what the ultimate impact is going to be. What I
20 can tell you is is that we are taking into account
21 these different effects in the TSPA model. I know
22 originally that, and they are correct, that the
23 statement was that tunnels will be soon be circular
24 for all time. We are now taking into account drift
25 degradation in our calculations, so it's part of the

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1 calculation.

2 CHAIRMAN GARRICK: Okay. Thank you.

3 MR. BOARD: Thanks.

4 CHAIRMAN GARRICK: There's no comments
5 from anybody? Okay. Any other questions? Comments?
6 Hearing none, we will adjourn for lunch. Get back at
7 1:15 -- 1:30.

8 (Whereupon, the foregoing matter went off
9 the record at 12:13 p.m. and went back on
10 the record at 1:32 p.m.)

11 CHAIRMAN GARRICK: Our meeting will come
12 to order.

13 This afternoon we're going to have a
14 presentation on the response to the external peer
15 review of the total system performance assessment, and
16 we're going to have a presentation on the total system
17 performance assessment Version 5.0 code. And I guess
18 we're going to do the peer review first. Is that
19 correct? And to do that we have John Peckenpaugh, and
20 why don't you proceed.

21 MR. CAMPBELL: John, I'm going to do a
22 brief introduction. I'm Andy Campbell. I'm Chief of
23 the Performance Assessment Section. And I just wanted
24 to make sure that people are going to understand that
25 we have two presentations today.

1 One, John is going to be talking about the
2 peer review and some of the outcomes of the peer
3 review that was done on TPA 3.2, and he'll talk
4 briefly about some of the changes that were made in
5 TPA 4.0 and 4.1.

6 And then, he'll be followed by Chris
7 Grossman, who will talk in some level of detail about
8 TPA 5.0, which is the code -- TPA code we're going to
9 run -- roll into licensing for review of issues while
10 we're doing a review of the license application.

11 And I just wanted to make sure that
12 everybody is aware that the purpose of our code is to
13 be a flexible and independent tool for reviewing both
14 prelicensing issues with DOE as well as licensing
15 issues that may come up in the course of a review of
16 the license application.

17 We believe that the enhancements to that
18 code, which are based on a variety of sources,
19 increase our capability and flexibility to evaluate
20 what the key issues are, and we also have increased
21 confidence in the code that it's an appropriate tool
22 for LA review.

23 So with those brief remarks, I'll turn it
24 over to John.

25 CHAIRMAN GARRICK: Okay. Thank you.

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1 Thank you.

2 Go ahead, John.

3 MR. PECKENPAUGH: Okay. My presentation
4 today will cover the response to the external peer
5 review of the total system performance assessment
6 Version 3.2 code. This presentation is based upon the
7 response to the external peer review which was
8 published in February of 2003.

9 Several staff members contributed to this
10 presentation. The main contributors were Lane Howard
11 from the Center for Nuclear Waste and Regulatory
12 Analyses, and James Firth from the NRC.

13 An overview of this presentation includes
14 the purpose and goals of the external peer review,
15 external peer review comments, staff responses to the
16 comments, TPA code changes, and a summary.

17 The rationale for performing the external
18 peer review of TPA 3.2 includes the following. In
19 October 1997, the ACNW recommended an external peer
20 review of the TPA code be conducted. The review was
21 conducted during the summer of 1999 to document both
22 the capabilities and the limitations of the TPA 3.2
23 code, and to evaluate the suitability for use in
24 reviewing the DOE license application.

25 NRC staff and others believed that an

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1 external peer review should help the NRC staff plan
2 enhancements to the TPA code in preparation for the
3 potential licensing review.

4 The external peer review complemented
5 other steps used to provide confidence in the TPA
6 code. Several years ago, the NRC staff decided that
7 it would benefit from independently developing its own
8 total systems performance assessment code, TPA.

9 This TPA tool has two primary purposes.
10 First, it is one of several tools used in prelicensing
11 reviews, and it's anticipated that it will be used in
12 the DOE license application. Second, it plays an
13 important role in helping the staff develop risk
14 insights to guide NRC reviews and other independent
15 investigations.

16 Because of the importance of the code in
17 review and risk insight activities, several measures
18 are used to provide confidence in the code results, in
19 addition to the external peer review. The code is
20 developed under a former quality assurance program.
21 Specific software controls are used to ensure that the
22 proper version is being used. Software validation
23 testing has been conducted. Appropriate use is made
24 of comparison with DOE results, benchmarking, checks
25 against analytic solutions, and the use of analog

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1 information.

2 The external peer review group, ERG,
3 consisted of eight members with expertise in rock
4 mechanics and mining engineering, volcanology,
5 hydrology, material science, and corrosion
6 engineering, geochemistry, performance assessment,
7 future events and processes analysis, and health
8 physics.

9 The last slide in your handout lists the
10 actual members of the ERG. Members of the ERG were
11 selected either by peer acclamation or by staff
12 recommendations. Selections were limited by conflict
13 of interest and availability of the potential group
14 members.

15 Purpose and goals of the external peer
16 review group were the following. The ERG was asked to
17 perform the following items pertaining to the TPA code
18 -- examine the methods and assumptions, recommend
19 improvements for future versions of the TPA code,
20 evaluate interpretations of conceptual models,
21 including parameter selections, determine whether the
22 NRC approach to TPA is sufficient to review the DOE
23 license application for the proposed Yucca Mountain
24 repository.

25 Each member of the ERG submitted an

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1 independent review. A consensus report was not
2 developed. However, the NRC did encourage the ERG to
3 communicate with each other. The NRC also held a
4 group kickoff meeting for the ERG with several days of
5 briefing and discussions.

6 The major external peer review comments
7 were the following. The code was well developed and
8 captured the important physical processes associated
9 with the repository. The code would be sufficient in
10 technical quality and flexibility to be used in the
11 review of the license application. However,
12 improvements would enhance the code.

13 Reviewers provided several suggestions for
14 implementation in the code, including comments on
15 modeling coupled processes, improving the modeling of
16 chemical composition of the water, data used in
17 modeling the saturated zone, basis for selecting the
18 radionuclides tracked, and code documentation.

19 ERG felt that the TPA documentation did
20 not explain the technical bases for the model
21 extractions, input data, parameter values, and
22 probabilistic approaches adequately. They also
23 believe that the overall transparency of the code
24 would be enhanced by preparing documents that explain
25 how features, events, and processes were included or

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1 excluded from the code.

2 Response to the external peer review
3 comments. Processing and tracking. A spreadsheet is
4 being used to track the resolution of the 233 unique
5 comments by the ERG. Comments were grouped according
6 to issue areas, assigned to appropriate NRC CNWRA
7 staff. Responses were developed and documented in the
8 final report. All comments were addressed. The
9 spreadsheet is periodically updated.

10 Staff responses to the comments. Most
11 responses to the comments did not require enhancement
12 to the TPA code. For example, some of the comments
13 pertained to project design changes by the DOE while
14 other comments pertain to other DOE issues.

15 Responses to comments that did result in
16 enhancement to the TPA code, responses -- or response
17 was addressed as TPA code changes in Version 4.0 or
18 4.1, or response would be considered in a future
19 version of the TPA code. And the current version is
20 TPA 5.0.

21 Currently, approximately 17 percent of the
22 comments have resulted in modification to the TPA
23 code. Responses to comments that were addressed
24 through improvements in the TPA code documentation --
25 justification was provided in User's Guide 4.0, or

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1 justification will be provided in User's Guide 5.0
2 when it is completed. Currently, approximately
3 12 percent of the comments require additional
4 documentation to the user's guide.

5 All comments were addressed in response --
6 in the response to the external peer review report.
7 The major responses to comments that have not been
8 previously mentioned are the following -- a citation
9 in the report of the documented sensitivity analysis
10 or other report that indicated that the issue or
11 comment does not affect the calculation.

12 And, finally, in response -- and the
13 report indicated that assumptions made in the modeling
14 or selection of parameters are reasonable. In some
15 cases, this required additional documentation.

16 TPA code enhancements, both external peer
17 review and staff generated. Based upon the
18 recommendations by the ERG and the staff, changes were
19 made in Versions 4.0 and 4.1 of the TPA code. I will
20 briefly discuss some of these changes. However,
21 changes in Version 5.0 of the TPA code will be covered
22 in a following presentation by Chris Grossman.

23 Changes in TPA 4.0 or 4.1 code. A number
24 of the recommendations for the TPA code modification
25 by the ERG were already being considered by the staff.

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1 Some changes in the TPA code were based upon ERG
2 comments. One example is a modification in the code
3 to provide the ability to specify different waste
4 package failure models -- bathtub or flow-through
5 models -- or different failure types.

6 Some changes in the code were based upon
7 staff recommendations. An example is when the code
8 was changed to modify the amount of water that can
9 enter the waste package by adding time-dependent flow
10 rate factors.

11 In summary, the external peer review
12 identified some areas of the TPA code that could be
13 improved. Several of the comments were addressed
14 within versions 4.0, 4.1, and 5.0 of the TPA code.
15 The external peer review of TPA 3.2 code provided
16 additional confidence that the code reasonably models
17 the repository system and is appropriate for use in
18 review of the DOE license application.

19 If you would like additional information
20 on the response to the external peer review of
21 TPA 3.2, I'd recommend that you examine the second
22 reference on this slide.

23 And this concludes my presentation. Are
24 there any questions?

25 CHAIRMAN GARRICK: Any questions?

1 MEMBER WEINER: You had a slide early on
2 -- I'm desperately trying to find it here -- that said
3 that the peer review panel decided that -- let me find
4 it. It said that the code was well developed and
5 captured the important physical processes associated
6 with the repository and would be sufficient in
7 technical quality and flexibility, and so on.

8 How did they -- can you say briefly how
9 they reached that conclusion? Or maybe the reverse.
10 What would they have needed to have found in order not
11 to reach that conclusion? That might be easier.

12 MR. PECKENPAUGH: Well, as I mentioned,
13 there were eight members on the panel, and each
14 developed their own responses. It wasn't -- they
15 didn't do it jointly.

16 And the staff then went through each
17 comment, and all of the comments of the different
18 panel members are presented as appendices in the
19 report that I referenced. And staff determined that
20 overall, based on the comments of the different eight
21 panel members, that they really -- they didn't have
22 severe objections to the way the code has been
23 developed to represent the physical system.

24 But they did have a number of comments,
25 which the staff has attempted to address either

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1 through changes in the code or additional
2 documentation in the user's guide or additional
3 explanation through siting of peer review journals and
4 additional documentation that were included in the
5 report.

6 I'm not sure if I really answered your
7 question.

8 MEMBER WEINER: You did answer it. The
9 other question is, during the course of the peer
10 review, were the results that you obtained, the output
11 of this code, compared with any other performance
12 assessment codes using the same or very similar
13 inputs?

14 MR. PECKENPAUGH: Well, I'll just briefly
15 discuss the process in which the peer review is
16 conducted, and maybe other people -- staff members can
17 then come in at the end to maybe add some additional
18 clarification.

19 But the peer review itself was conducted
20 over a fairly short period of time during the summer
21 of 1999 over less than three months. And the way it
22 was initially set up, the staff was given -- not the
23 staff, but the panel members were given TPA 3.2 code,
24 and the user's guide for TPA 3.2, and then a NUREG
25 that has some information on sensitivity analysis and

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1 uncertainty that was run on the previous version of
2 the code. I think it was 3.1.

3 And they looked these documents over over
4 a period of about six weeks or so, and then they met
5 in San Antonio for a number of days to have this --
6 what they call a kickoff meeting, and then they were
7 briefed by the staff and they had a chance to have
8 questions back and forth.

9 And then, they went back and I think it
10 was over -- I think it was a two- to three-week period
11 after -- excuse me, a three- to four-week period they
12 had to finalize the review and submit their written
13 reports.

14 MEMBER WEINER: So the answer to the
15 question, did they compare the outputs to any other
16 performance assessment code, the answer is essentially
17 no.

18 MR. PECKENPAUGH: Well, they did ask, and
19 they had the opportunity to ask for additional
20 information from the NRC, and we did provide that.
21 But I don't know if we actually provided any other
22 codes to them to look at or not.

23 MEMBER WEINER: Okay.

24 MR. PECKENPAUGH: I don't believe so,
25 but --

1 MR. WITTMAYER: John and members of the
2 ACNW, this is Gordon Wittmeyer, staff at the Center in
3 San Antonio. We didn't do the explicit comparison of
4 the results of our TPA code, then Version 3.2, to the
5 DOE results. I think, though, that a number of the
6 individual reviewers consulted DOE reports.

7 I don't think they looked at the
8 performance assessment results, but they certainly
9 looked at the DOE model extractions or saturated zone
10 flow for geochemistry. I think also for waste package
11 models.

12 MEMBER WEINER: Thank you.

13 CHAIRMAN GARRICK: George?

14 MEMBER HORNBERGER: Yes. It's been a
15 little while since I read the external peer review,
16 and I will admit that although I've gotten the second
17 volume that you have on the screen up there I haven't
18 had a chance to look at it yet. So forgive me if I'm
19 not totally up to date on everything.

20 You gave just a couple of quick examples,
21 John. And in particular, you said, "Well, okay.
22 Based upon ERG comments, the ability to specify
23 different waste package failure modes, etcetera,
24 bathtub," that that was a change. Did you pick that
25 example because that was the most -- thought to be the

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1 most important comment that you got from the peer
2 review? Or if it isn't, could you tell me what you
3 think are the three top comments you got that led to
4 changes in the code?

5 MR. PECKENPAUGH: I'll answer your second
6 question first. I'm not sure I can answer which were
7 the top three. But there is a little bit of
8 uncertainty within the -- based on the comments, which
9 ones were entirely from the -- we know what comments
10 came from the ERG. But in many cases, the staff felt
11 a -- and in some cases they were already working on
12 making some of these changes in the code anyway.

13 MEMBER HORNBERGER: Right.

14 MR. PECKENPAUGH: So I tried to pick one
15 example that we felt was definitely a comment that the
16 staff wasn't anticipating doing any work on, and
17 that's why I selected that one.

18 Now, other staff members might have a
19 better feel for your second question.

20 MEMBER HORNBERGER: Yes. Gordon, aren't
21 you going to weigh in on that one?

22 MR. WITTMEYER: The other comment that
23 comes to mind that -- where the one member had extreme
24 concerns was about saturated zone flow and transport.
25 And that was based on, at least at that time, the

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1 relative absence of data in the alluvium.

2 I think that since that time we've
3 certainly - the DOE and Nye County have gathered more
4 data, and the Center staff in hydrology have developed
5 much more refined process-level models, and we still
6 use the same basic extraction. You know, development
7 of a manifold -- from the repository location to the
8 receptor location.

9 But we have addressed that, and that has
10 really been, you know, largely due to time and more
11 data being gathered. I'm trying to think if there are
12 others that come to mind. I think the usual concerns
13 about coupled processes and how they are linked in
14 something that -- like the TPA code, which really
15 functions in a serial fashion. We've only been able
16 to address that by doing a better job of establishing
17 end states for various coupled thermal hydrologic
18 chemical processes.

19 I'd ask other people here and at the NRC
20 if they recollect anything else that was, you know, a
21 big ticket item from the ERG.

22 MR. McCARTIN: Yes. Tim McCartin, NRC
23 staff. One comment, not so much towards the code
24 itself but towards the documentation that I remember,
25 the way the peer review -- as John described, they had

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1 the documentation, and then we had the meeting. And
2 they came to the meeting with a lot of questions, and
3 actually at least two or three of the members, maybe
4 more, felt we had done a very superficial job based on
5 the documentation.

6 Having heard us explain everything that we
7 had thought through in getting to the extracted
8 models, etcetera, they said, "You really sold yourself
9 short with your documentation. You actually have
10 considered a lot more than what you've put down
11 there." And, of course, they wanted us -- you need to
12 do a lot more documentation of this now.

13 Part of that is, well, the Department of
14 Energy will, in their application as a review tool --
15 we felt we didn't have to do quite as much. But it
16 was an interesting perspective that in developing the
17 user's manual we certainly weren't as comprehensive as
18 when we explained things. And that was an interesting
19 part of the -- some of their perspective on what they
20 read. And I think Dave has some --

21 MR. ESH: This is Dave Esh with the NRC
22 staff. I can add to your first question about where
23 the changes come from basically. TPA 4.0 and 4.1 were
24 at least under discussion, and I would even say under
25 development whenever the TPA 3.2 peer review was

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1 ongoing.

2 So it's really hard to put your finger on
3 -- it's a chicken/egg type of thing, who came up with
4 it first. Well, that really isn't important to us as
5 long as the important changes got made.

6 One change that I can think of when you
7 asked about top three, I think we had a number of
8 comments from our geochemistry representative. And
9 some of our models were pretty crude, and a geochemist
10 might say they are still crude, but that's an area
11 that I think we improved a lot. And maybe Chris
12 Grossman might say something about that during his
13 presentation.

14 VICE CHAIRMAN RYAN: Dave just answered my
15 question.

16 CHAIRMAN GARRICK: Oh, good.

17 I wanted to comment on one thing. You
18 indicated that you didn't have an integrated report
19 from the peer reviews, but you had individual reports.
20 But as I recall, there was a lot of interaction among
21 the peer reviewers, were there not?

22 MR. PECKENPAUGH: Yes. And it was
23 encouraged to, as I mentioned -- that the external
24 peer review group were encouraged to talk back and
25 forth or call back and forth to discuss things with

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1 each other. I mean, that was not prohibited. We
2 actually actively encouraged them to do that, and they
3 were encouraged also to ask for additional documents
4 if they felt it would be useful to them, too.

5 CHAIRMAN GARRICK: Yes. One other thought
6 here. I notice in the issues that you've identified
7 that none of them were -- had to do with the
8 probabilistic issues, and I would have expected some
9 of those. Is that because everybody was satisfied
10 with the way you handled probabilistic issues? Or is
11 it because it was a lack of expertise on the peer
12 review in that area?

13 MR. PECKENPAUGH: I'm going to have to
14 defer that to some of the other staff members that are
15 more familiar with that area.

16 MR. WITTMAYER: This is Gordon Wittmeyer
17 at the Center in San Antonio. Brian Thompson was
18 probably our foremost expert in probabilistic methods
19 who was on the external review group. He did make
20 some comments not about the -- it's not about the code
21 in general, but he had some comments about the use of
22 unbounded distributions, which would be something we
23 need to check with in building our input data.

24 He also had some comments about our
25 sampling procedures, about whether we needed to

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1 consider switching from Latin hypercube to perhaps
2 something that -- you know, an important sampling
3 method to do a better job of giving the extremes of
4 the output distribution well defined.

5 Those are things I don't think we -- the
6 latter we haven't done anything in detail recently.
7 We certainly are going back as we do versions of the
8 code and trying to develop more technical basis for
9 the input distribution, the input parameter
10 distributions, make sure that the tails don't stretch
11 off into a region that's not physically possible or
12 plausible, comments in that general area.

13 CHAIRMAN GARRICK: Were there any comments
14 regarding having built-in algorithms for updating data
15 using, for example, inferential methods such as
16 Bayesian updates?

17 MR. WITTMAYER: I do not recall.

18 CHAIRMAN GARRICK: Okay.

19 MR. WITTMAYER: There may have been, but
20 I certainly don't recall that.

21 CHAIRMAN GARRICK: Okay. Any other
22 questions?

23 MEMBER WEINER: I have --

24 CHAIRMAN GARRICK: Thank you. Okay, Ruth.

25 MEMBER WEINER: -- one more to whoever

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1 wants to answer it. Did the reviewers -- were the
2 reviewers able to structure their own distributions
3 from the input data, or is this something that the
4 code did? And did you get any comments on that
5 question?

6 MR. WITTMAYER: This is Gordon Wittmeyer
7 at the Center again. We did not ask them to conduct
8 any sort of a -- you know, well, we didn't conduct an
9 expert elicitation to try and get new data from them.
10 And I don't recall -- I frankly don't recall if any of
11 them reanalyzed any of the information that was
12 provided in the documents on process-level models to
13 see whether or not they would have a different take
14 on, you know, the distributions we abstracted for
15 input parameters.

16 MEMBER WEINER: My question was not, did
17 they provide new data, but for the waste isolation
18 pilot plant, we put out a little volume that said
19 essentially, "If your data looks like this, this is
20 the kind of distribution we recommend." And I
21 wondered if they could -- taking whatever data they
22 had, if they structured their own distribution or if
23 you gave them guidance.

24 MR. WITTMAYER: We didn't really address
25 that topic. We didn't discuss things like whether or

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1 not we should always use maximum entropy type
2 distributions or anything like that in this external
3 review.

4 MEMBER WEINER: Thank you.

5 CHAIRMAN GARRICK: Just as a kind of a
6 follow-on to that. There are a number of PRA codes
7 around the country that have excellent data packages
8 in them that have full updating capability and
9 processing capability that, you know, you may want to
10 look at in terms of possible modifications for your
11 own code.

12 And I don't know what data packages you
13 have in your code, but I do know that in a number of
14 PRA code packages the distinguishing feature between
15 the really good ones and the not so good ones has been
16 the capability in the code to process data. And as I
17 say, I don't know how far you've pushed the TPA in
18 that arena, but it is something you may want to
19 consider. It's certainly something you don't need to
20 start from scratch on.

21 Anything -- any other questions? Yes,
22 Mike.

23 MR. LEE: Just one question. On slides 3
24 and 12, you make reference to confidence-building
25 measures that kind of developed as a result of peer

1 review. In some parlances, confidence-building has
2 also been referred to model validation, which gets
3 everyone's Irish up if you will, because it means many
4 things to many people.

5 But are there plans to do additional
6 confidence-building in relation to the -- how the code
7 models the system, the repository system at Yucca
8 Mountain, especially in light of the fact that both
9 NRC and DOE take different views on the behavior of
10 the vadose zone, unsaturated zone hydrology?

11 MR. PECKENPAUGH: Well, I mentioned that
12 we did do -- we have done software validation testing.

13 MR. LEE: But that's --

14 MR. PECKENPAUGH: That's --

15 MR. LEE: That's kind of getting into
16 evaluating the numerical capability of the code --

17 MR. PECKENPAUGH: Right.

18 MR. LEE: -- which is -- some people call
19 verification, but, I mean --

20 MR. PECKENPAUGH: Right.

21 MR. LEE: -- aside from that, is there --

22 MR. PECKENPAUGH: You'd have to address
23 that to other staff members.

24 MR. LEE: You alluded to work on
25 algorithms. Are you comparing C-well test results

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1 with how the -- what comes out of the stream tube
2 analysis that Gordon referred to a little bit?

3 MR. MCCARTIN: Tim McCartin, NRC staff.
4 Well, certainly, from the NRC staff standpoint, there
5 is the key technical issue people, the discipline
6 people, that are looking at the DOE information. We
7 certainly look at it in PA, but as both Center and NRC
8 scientists are looking at the DOE information.

9 In terms of our particular code, I mean,
10 it's more of a review tool. And we have an ability to
11 look at a variety of different ways. It depends on
12 what the Department comes in with.

13 MR. LEE: Okay. Thank you.

14 MR. ESH: Yes, this is Dave Esh. I would
15 add to that, Mike, you know, that we -- take, for
16 example, the spent fuel dissolution. We have
17 basically four different data sets, or you could call
18 it conceptual models that we can implement to look at
19 effects of that change.

20 But to answer your question very directly,
21 we haven't done a validation exercise per se to say
22 which one of those applies. We just have the
23 flexibility to use any one of those as we may, so --

24 MR. LEE: Okay. I wasn't implying that
25 the same level of validation was necessary in the NRC

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1 code as in DOE's code, because the burden falls on
2 DOE. I was just curious as to what level of --

3 MR. ESH: John mentioned the software
4 validation testing, and you're correct that that's
5 different than conceptual model validation.

6 MR. LEE: Right.

7 MR. ESH: But even that software
8 validation testing has elements of model validation in
9 it. There were some elements in that test plan of
10 comparing code models to experimental results, seeing
11 how they compare that sort of thing.

12 MR. LEE: Sure. Okay. Thank you.

13 CHAIRMAN GARRICK: Any other questions or
14 comments? Thanks, John.

15 Chris?

16 MR. GROSSMAN: Just one second, please,
17 while I get the slides set up.

18 (Pause.)

19 Okay. I want to thank you for inviting us
20 to talk about the external peer review and the
21 modifications that we've made to the TPA code. And
22 before I go too much further, can you hear me through
23 the microphone system? Okay. Sorry.

24 My name is Chris Grossman, and I am a
25 member of the performance assessment staff here in the

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1 Division of Waste Management. And I've been kind of
2 the point person for the TPA code, but I wanted to
3 make it clear that the TPA code is a big effort of the
4 performance assessment group and the staff in general,
5 and it encompasses a lot of people, both here and at
6 the Center. A lot of people put a lot of time and
7 effort into this code to make it what it is.

8 So as the point person, I get the honor of
9 coming before you to present the information. If you
10 recall, last March this committee held a workshop or
11 a working group on performance assessment in which
12 members of the staff came and presented on the TPA
13 code. And at that meeting we had the opportunity to
14 present -- to give staff's envision of what the role
15 of the code is in the process for Yucca Mountain.

16 We provided an overview of the conceptual
17 models within the code, as well as some specific
18 details regarding the source term modeling, and then
19 also a brief understanding of the results that have
20 come out of the code.

21 And so I would refer some of the newer
22 members of the committee back to that presentation or
23 those sets of presentations in March for a fuller
24 overview of the entire code. The presentation I'll
25 talk about here today deals more with just the

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1 modifications that have been made between 4.1 and 5.0.

2 I'd like to start off providing just a
3 brief overview, and first I want to reiterate what our
4 vision is for the code -- the review of a potential
5 license application for Yucca Mountain.

6 Next, I'd like to step through briefly
7 just the development process. I don't want to bog you
8 down in the details of the process, but to give you an
9 idea of how this occurs here and at the Center, follow
10 that up with the role that the external peer review --
11 tying this in with John's presentation of how the
12 external peer review played a role in TPA 5.0
13 modifications, and then get to the meat of this talk,
14 which are the -- some of the significant modifications
15 or what I'll call major modifications that were made
16 for 5.0, and then conclude with the path forward and
17 a vision for how we intend to use the code going
18 forward.

19 So starting off with our vision of what
20 TPA -- of how TPA fits into the program, it is a
21 review tool. And unlike the Department of Energy's
22 TSPA model, which will be a compliance demonstration,
23 the TPA code was developed specifically with this task
24 in mind of being a review tool and not a compliance
25 demonstration.

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1 It does allow us to have an independent
2 capability to test and probe DOE's model. And where
3 possible, as we develop that independent capability,
4 we base it off of fundamental principles and available
5 data.

6 We also -- two other considerations that
7 we take into account when developing the code are
8 flexibility, so that we can evaluate a lot of
9 different scenarios so to speak, or different cases in
10 DOE's case, whatever that might be, because that's an
11 evolving -- I'll refrain from using the term I was
12 thinking, but it's an evolving document.

13 And, finally, we also consider
14 computational efficiency. The code is really no good
15 to the staff if we can't use it quickly to get the
16 results we need. We can't be burdened with -- it
17 would be troublesome to be burdened by lengthy
18 algorithms and calculations.

19 A brief overview of the development
20 process. Basically, the planning for TPA 5.0 began
21 back in 2001, which is actually shortly before I
22 started. But at that time, staff identified
23 modifications that we felt would enhance the
24 capability. And we based these modifications or these
25 proposed modifications off of criteria, which I'll

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1 explain a little bit later, that we used to decide
2 what got in and what didn't at this point.

3 The modifications are described in the
4 software requirements description, which I believe was
5 provided to the committee in advance of the meeting.
6 And the specific implementation of these modifications
7 are documented in a series of software change requests
8 at the Center, which is kind of a QA tool as we
9 develop the code.

10 The development activities then continued
11 through this past summer. In July 2003 is when they
12 wrapped up. And then, the end of the development I
13 should note coincided with some confirmatory testing
14 activities which was another confidence-building
15 activity.

16 In the planning process we used several
17 sources to arrive at proposed modifications. Notably,
18 the external peer review was considered, and the
19 responses we had from the peer reviewers. We also
20 relied on our review of DOE documents, the TSPA SR and
21 the supplemental science and performance analyses, as
22 well as using the TPA code, past versions of the code,
23 and the experience we've gained from that.

24 And then, finally, a discussion among the
25 KTIs and what processes would be desired to be

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1 considered within the code. And, finally, the
2 modifications that were identified were meant to
3 enhance our capability to review a potential DOE
4 license application.

5 Some of the specific criteria that we used
6 when determining potential modifications are listed
7 here on the slide. Most notably, we had to be ready
8 -- we had to prepare our capability to review
9 potential license application from DOE for Yucca
10 Mountain. So that's kind of the chief criteria.

11 Secondly, would the modification improve
12 staff understanding of the repository system? And
13 this relates to other areas in terms of developing our
14 independent understanding and determining -- not
15 determining but having an idea of what's important
16 within the system.

17 The final two criteria, as I mentioned
18 earlier -- I'll reiterate those -- is we'd like to
19 enhance the flexibility in our models, and the input
20 and output, so that we can handle a lot of different
21 cases, if possible, and then also maintain
22 computational efficiency.

23 I'd like to note at the end that many of
24 the modifications that met these criteria were also
25 recommendations from the external peer review.

1 Okay. So kind of the heart of the matter
2 here, what modifications were made, and the conceptual
3 model modifications -- and I'm going to break these
4 into two categories, which are kind of my own doing.
5 I'll call them major and minor. And this terminology
6 doesn't really relate to significance or risk
7 significance or anything. It's just some were more
8 complex or bigger tasks than others, so I'm going to
9 dwell on those -- on the major modifications as
10 opposed to the minor enhancements to the existing
11 conceptual models.

12 The minor enhancements are included in
13 supplementary material at the back of the
14 presentation, so that you can get a sense of some of
15 those. And then there are also modifications to the
16 executive driver of the code, which were really mostly
17 to accommodate flexibility and new data that
18 characterize the system.

19 And, again, I just want to reiterate that
20 -- and the following slides are not going to talk to
21 the entire code, but just some of the major
22 modifications.

23 So the first one, and what I consider kind
24 of a big one, is near-field chemistry. We added a new
25 conceptual model to describe the chemistry that is

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1 considered important for corrosion modeling. And just
2 to note that this was also one of the external peer
3 review recommendations dealing with near-field
4 chemistry.

5 But essentially here, if you consider
6 their three periods for the repository system -- you
7 have before a thermal dryout period, you have during
8 a thermal dryout period, and then following a thermal
9 dryout period -- and this conceptual model deals
10 largely with during the dryout period.

11 And what we have is -- it's considered the
12 critical period for corrosion, because what you have
13 is evaporation processes going on, and you are
14 concentrating brines on the surfaces of the engineered
15 barriers. And if we were to attain a high relative
16 humidity during this time, it could lead to delicate
17 questions of the salts in which a thin film of water
18 forms on the salts -- on the surfaces.

19 This combination of the high relative
20 humidity with the increased concentration of species
21 such as chloride, which are important to the corrosion
22 chemistry, could lead to an increased chance of
23 localized corrosion.

24 So the Center did some extensive process-
25 level modeling using equilibrium software to develop

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1 a range of chemistry that is sampled in the code.
2 That range of chemistry covers the concentrated
3 brines. And what we find, then, from this model is
4 that it leads to an increased chance of localized
5 corrosion. And when we do see -- whereas in the past
6 we saw little to none, we're now seeing some in a few
7 more realizations.

8 The other two areas I talked about were
9 before dryout and after dryout. The model -- the way
10 the model abstracts those two periods is that before
11 and after they're done similarly, and right now they
12 are based on ambient poor water, the J-13 water.

13 The code also has the flexibility to
14 specify chemistry as a function of temperature,
15 although that data is not currently in the code.

16 The second area, as we kind of move
17 through serially, of the code -- the drip shield, and
18 I'll talk a little bit about the model here for the
19 drip shield lifetime. There are actually two
20 improvements to the drip shield which was in a
21 previous version in a different form.

22 The first one which I'm going to deal with
23 deals with corrosion of the drip shield, and more
24 specifically general corrosion. The second one, which
25 is the drift degradation effects on the drip shield,

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1 were talked about this morning. So I'm not going to
2 go into those in too much detail. You may have had
3 more than your fill for the day for that topic.

4 CHAIRMAN GARRICK: You may be right.

5 (Laughter.)

6 MR. GROSSMAN: This upgrade to the drip
7 shield model was done to improve some of the realism
8 in the code, and we use -- what we do is we use data
9 for titanium-7 to develop a range of corrosion rates.
10 And this data is similar to what was used before to
11 develop the distribution failure times.

12 And that range of corrosion rates are then
13 sampled, and we calculate a drip shield thickness
14 versus time, based on degradation to general
15 corrosion.

16 Here the failure time affects -- the drip
17 shield, again, affects the water contacting the waste
18 package, and the code offers the flexibility to
19 specify different chloride concentrations on the waste
20 package. Some of the output from this change doesn't
21 really result in any major change from previous
22 versions, largely because it's built on the same data
23 that was -- or similar data to what was used before.

24 And then, as I mentioned, there was also
25 the MECHFAIL edition, but I'll leave that.

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1 Moving on to the waste package, then, we
2 added a new model to describe weld corrosion, and this
3 was done largely to enhance our review capability.
4 Based on a review of the site recommendation, it was
5 found that DOE was attributing most of the doses
6 during the compliance period to diffusion through
7 stress corrosion cracks. So this model was kind of
8 developed to help our capability to review that.

9 Essentially what happens here is that you
10 have small failures in the weld areas, and what this
11 graph shows -- I'll use this. Okay. Keep in mind for
12 their corrosion abstraction -- is that if the
13 corrosion potential goes above the repassivation
14 potential, then we see an increased chance for
15 localized corrosion.

16 So on this graph we have some data that
17 the Center developed for thermally-aged specimens, and
18 these were aged five minutes at 870 degrees Celsius.
19 And this is alloy-22, and the solid line represents
20 the mill-annealed, which would be essentially the
21 alloy-22 on the waste package itself. And the dashed
22 line represents the aged alloy-22.

23 And what we see is that the repassivation
24 potential is lower for the thermally-aged than it is
25 for the mill-annealed, which suggests that it could

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1 possibly experience an increased potential for
2 localized corrosion. So we use this data, then, to
3 bound areas for parts of the waste package such as the
4 weld, which would be in some sense thermally-aged due
5 to the welding process.

6 The abstraction, then, is similar to our
7 waste package corrosion modeling, with the exception
8 that we use parameters tailored to the weld areas.
9 What this does is when weld failure occurs, then it
10 affects the amount of water entering the waste
11 package, which is a function of the geometry of the
12 weld area.

13 It turns out to be kind of a minor effect,
14 and that's largely due to the fact that in practice
15 the parameters used for the weld area didn't result in
16 much change from the actual waste package. And what
17 you see is that though you have some weld failures
18 earlier, that the waste package actually coincides
19 fairly closely to the weld area. So it doesn't result
20 in a large difference in the new code.

21 Moving on to the source term, then, we
22 added a new model to evaluate high-level waste glass,
23 which was not previously in the code. And this was
24 added largely to evaluate DOE, which does take -- or
25 does account for high-level waste glass.

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1 The model is analogous to the spent
2 nuclear fuel model, and the data -- there were many
3 experiments completed to determine the dissolution
4 rates, and so there's lots of estimated rates.
5 However, those rates are dependent on many variables,
6 which I've listed some here -- the glass formulation
7 methods, testing methods, test conditions themselves.

8 For our model we chose a path similar to
9 DOE's, and what we have are a forward dissolution
10 rate, which slows as the silica builds up in the
11 system. And then, we also -- the intrinsic
12 dissolution rate, which -- excuse me -- which is --
13 this K goes here, and that's a function, then, of
14 temperature and pH.

15 And it's important to remember that
16 temperature dependence -- because what we've seen is
17 that in some cases, particularly during the
18 temperature spike, the glass can in fact exceed
19 releases of the spent nuclear fuel. But over longer
20 terms, the spent nuclear fuel comes back because of
21 the larger inventory and --

22 CHAIRMAN GARRICK: Chris, does the code
23 allow you to consider a mix of different water
24 compositions? In other words, if the evidence
25 indicates there is -- X is going to be this

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1 composition, and Y percent chance that it's going to
2 be some other composition, and Z some other, can you
3 accommodate that?

4 MR. GROSSMAN: For this particular model
5 or --

6 CHAIRMAN GARRICK: Well, for this one, and
7 for the spent fuel model.

8 MR. ESH: This is Dave Esh with the NRC
9 staff. Yes, I think you could. It would be a little
10 tricky, but we have user-defined distributions, that
11 you could basically make a user-defined distribution
12 to define the intrinsic dissolution rate, for
13 instance, that would be representative of, say, and
14 acidic condition or a basic condition.

15 You could do the same thing with the spent
16 nuclear fuel model. You could define a user
17 distribution that would represent the likelihood of --

18 (Approximately 45 seconds of proceedings
19 lost due to house audio system failure.)

20 MR. MOHANTY: This is Sitakanta Mohanty,
21 staff. For any conservative approach without taking
22 into account any trend for reverse reaction. So we
23 only implemented the forward reaction in the model.

24 MR. GROSSMAN: Thank you.

25 MEMBER WEINER: Thank you.

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1 MR. GROSSMAN: Okay. The other areas, as
2 I mentioned earlier, based on review of the DOE's new
3 documents, we have had diffusive release in previous
4 versions of the code. It was removed largely because
5 it was found not to be too risk averse for our code.

6 But based on what we've seen, and some of
7 the results that we reviewed in our SR documents, we
8 decided that adding back into the code to enhance our
9 review capabilities DOE might be a good idea. And
10 so the modification was made.

11 Essentially, the abstraction for the
12 diffusive release involves transport through films
13 both inside and outside of the waste package. And
14 here the user defines the length of the transport path
15 as well as the thickness of the cross-sectional areas.

16 What we find is that the thickness tends
17 to be a limiting parameter, but it's so small -- it's
18 on the order of -- the assumed thickness we use is on
19 the order of 10^{-8} square meters. That it's shattered
20 by vector release, still, so it hasn't changed much
21 between different versions, but it's in there for our
22 review capability.

23 And the last piece for the source term
24 would be colloidal release, and this was added to --
25 as well to enhance our review capability of the DOE

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1 model. DOE has a rather complex colloidal model, and
2 our model is based off theirs, but I would
3 characterize it as somewhat more simplified.

4 This, by the way, was also an external
5 peer review recommendation. The colloidal release and
6 transport was similar to DOE's, and the way we
7 abstracted it is a fraction of the release is
8 specified as irreversibly absorbed to colloids. These
9 colloids then become distinct species with their own
10 transport properties, which can transport out of the
11 engineered barrier, through the unsaturated zone,
12 saturated zone, to the biosphere.

13 In the UZ, the radionuclides irreversibly
14 absorbed to colloids -- can be filtered out in the
15 matrix. However, we don't account for any retardation
16 within fractures. And that filtration -- I should
17 mention the UZ is a permanent filtration. They are
18 completely removed, then.

19 In the saturated zone, we model it with
20 retardation in the fracture top in the alluvium, and
21 that's -- some of the distributions that we use in the
22 code are here on the left. For the fracture tuft,
23 this was abstracted from data on the C-wells
24 microsphere test. And for the alluvium it was
25 developed from theoretical calculations for the

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1 retardation.

2 In terms of radionuclides reversibly
3 absorb to colloids, we don't explicitly treat that,
4 but one way we deal with that is if we can modify the
5 transport parameters for the dissolved species to
6 account for that reverse absorption.

7 In terms of the impact of this change on
8 the code, we're still evaluating that at this point.

9 Okay. The unsaturated and saturated zone
10 flow and transport. The big change for these parts of
11 the code was time -- radionuclide transport parameters
12 to the geochemistry that's encountered on the
13 transport paths. And we thought this would be a good
14 improvement to the realism in the code, and it was
15 also a recommendation of the external peer review.

16 Essentially, what was abstracted here is
17 that we used process-level modeling to calibrate our
18 response surface to experimental data, and some of
19 that data was developed at the Center and some was
20 taken from literature sources.

21 This occurs for the actinide elements
22 only. The other elements are still modeled as they
23 were in the past. And essentially, what we have is
24 you can see a typical response curve. I think this is
25 for neptunium. This was, in fact, developed at the

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1 Center. We sampled the partial pressure carbon
2 dioxide and pH, which are sampled over ranges that are
3 representative of Yucca Mountain waters. And then, a
4 retardation factor is calculated based on those two
5 sample parameters for that element.

6 We found that this improved some of the
7 efficiency over the old method, which they had to be
8 sampled with the Latin hypercube sampler, which tended
9 to be slower than the current method. And it also
10 results in a narrower range of retardation factors
11 than we had previously.

12 CHAIRMAN GARRICK: Did you say a narrower
13 range?

14 MR. GROSSMAN: Narrower range, yes.

15 Okay. And then, the -- I believe this is
16 the final -- yes, this is -- the final modification
17 I'd like to talk about deals with the disruptive
18 scenarios, and particularly igneous activity. And we
19 added an ash redistribution model to allow some
20 flexibility to look at remobilization parameters and
21 the importance of those parameters.

22 In the past, we had modeled long-term
23 remobilization. This new model, which is kind of
24 represented here by this box diagram, improves on that
25 by adding some quickly remobilized contaminated ash.

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1 Essentially what we have in this model is you have
2 three inputs. You have waterborne erosion of
3 contaminated ash, airborne erosion of contaminated
4 ash, and then kind of a dilution factor, the
5 uncontaminated airborne erosion.

6 And then, as I mentioned, under this
7 waterborne erosion you have three classes. You have
8 the quickly mobilized, moderately mobilized, and then
9 long-term mobilized.

10 The parameters were based on process-level
11 modeling in some cases, and then existing data -- I
12 believe some of the data came from USGS for the
13 uncontaminated airborne erosion.

14 What we see with this model -- and we're
15 still evaluating this, but what we've seen so far is
16 that in the old version of the code with the long-term
17 immobilization you had this rapid spike followed by
18 decay off. In this version, what we've seen so far is
19 kind of a rapid spike followed by a slight increase to
20 that immobilized fraction, and then a tailing off due
21 to the decay and removal from the RMEI.

22 So to conclude, I hope I have provided an
23 indication here of how some of the modifications that
24 we included in the TPA code enhance our review
25 capability. We feel they improve the realism of the

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1 code and also the flexibility that we have with the
2 code. I think staff is confident that the code will
3 be an effective review tool based on the past versions
4 and the current modifications that we've included this
5 go-round.

6 We plan to continue to evaluate parameters
7 and complete confirmatory testing to increase our
8 confidence in the code and its output. And we also
9 plan to continue to use the TPA code to assist our
10 reviews and improve our understanding as we go
11 forward.

12 And with that, I'll end the talk and open
13 the floor to questions.

14 CHAIRMAN GARRICK: Okay. Questions?
15 Ruth.

16 MEMBER WEINER: You mentioned that you
17 include an equilibrium code. Which one?

18 MR. GROSSMAN: The equilibrium model -- it
19 was done offline, and then the data was -- it was
20 brought in.

21 MEMBER WEINER: Yes. What --

22 MR. GROSSMAN: It was EQ36 I believe is
23 what it was.

24 MEMBER WEINER: That's what I -- that was
25 what I imagined you had used.

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1 On your colloid slide, you mentioned that
2 the actinides are bound to colloids. What's the
3 colloid? And did you consider that plutonium-4 is
4 itself -- forms colloids? It almost doesn't dissolve;
5 it forms colloidal --

6 MR. GROSSMAN: Yes. I'm going to actually
7 turn that question -- is David Pickett available at
8 the Center? He is kind of the expert there.

9 MEMBER WEINER: Oh, here's your colloid
10 expert.

11 MR. PICKETT: Yes. This is David Pickett
12 at the Center. There is nothing explicit about how
13 the colloids are assumed to be irreversibly bound. It
14 will be taken into account that DOE data suggesting
15 permanent attachment to waste form colloids, but also
16 data that suggests that attachment of plutonium and
17 perhaps americium to, for instance, iron oxyhydroxide
18 colloids is very slowly reversible, so that it could
19 be considered irreversible for transport
20 considerations.

21 MEMBER WEINER: Did you consider the --

22 MR. PICKETT: What was the other part of
23 the question?

24 MEMBER WEINER: Did you consider the
25 formation of colloids from the actinides themselves?

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1 Plutonium-4, oxidation state 4, forms a colloid. It's
2 not -- it's not a true solution.

3 MR. PICKETT: Right. Not explicitly. And
4 I guess the consideration being that you're unlikely
5 to maintain the -- presumably, you mean because you're
6 reaching the saturation state of the plutonium, so
7 you're forming colloids.

8 MEMBER WEINER: No. It forms a colloid.
9 It exists as a colloid, and we have a lot of data to
10 back that up. The reason I'm asking the question is
11 that the mobility of colloids is something about which
12 there is a great deal of uncertainty, and it depends
13 very critically on what assumptions you are making
14 about what the colloidal substance itself is, what
15 size it is, what the surface of it is.

16 MR. PICKETT: Yes. And our model can
17 accommodate those types of considerations. You can
18 adjust how much you think is being transported
19 colloiddally and also the size characteristics of that,
20 and so forth. But that is done offline, and then you
21 alter your input data to try to simulate those types
22 of considerations.

23 MEMBER WEINER: Yes, that is what's
24 important. What pH range did you use for your
25 colloidal mobility? What pH range do you put into

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1 your model?

2 MR. PICKETT: Part of the simplification
3 that we've used here is we're not explicitly
4 considering the pH range. But offline, as we consider
5 the concentrations that are possible, we will consider
6 the pH -- the solution. But that's not in the model
7 explicitly.

8 MEMBER WEINER: Okay. Thanks.

9 I have another question for you, Chris.
10 Can you give me some -- an example of where your TPA
11 is -- where a TPA designed for review differs from a
12 TPA designed to assess performance? Just an example
13 of what the difference is.

14 MR. GROSSMAN: Yes, I can give you a
15 generalized version. I mean, one thing that we look
16 at is you've heard the word "flexibility" mentioned a
17 lot, and maybe the colloidal model might be the one to
18 go with, since we're talking about that.

19 You can't explicitly -- or we don't
20 explicitly model true plutonium colloid with this
21 extraction, but it can be done through the
22 flexibility. And I think that that may be one area as
23 with -- with our tool we are able to analyze different
24 situations by kind of finagling code, so to speak.
25 Whereas I think for DOE and a licensing type of code

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1 there would be a much larger burden of proof to
2 provide a technical basis and validation of the
3 conceptual models, and so forth, than might be needed
4 for the review tool.

5 CHAIRMAN GARRICK: George.

6 MEMBER HORNBERGER: Yes. Just -- I had
7 somewhat the same -- one of the same comments as Ruth,
8 and I'd just like to emphasize or suggest to you that
9 in part it should be semantics. I understand that
10 when you treat colloids you are doing this offline,
11 and I understand how you're doing it in a TPA code.

12 But when you -- our former member Ray
13 Wymer always went crazy because to him there were
14 colloids and pseudo-colloids, with plutonium-4 being
15 a colloid and the iron oxyhydroxides being pseudo-
16 colloids. And you only talk about them being
17 irreversibly bound, and that's what raises the
18 question in the minds of people who think about
19 colloids.

20 So I think you should just be a little
21 more circumspect in how you do your description. It
22 doesn't make any difference to how you do your TPA.

23 I have a general question, Chris. So,
24 let's see, when was the first version of TPA?

25 MR. GROSSMAN: Probably about the time I

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1 was born.

2 (Laughter.)

3 MR. LEE: '88 or '89. It was published as
4 IPA Phase 1.

5 Tim, do you have a better --

6 MEMBER HORNBERGER: The exact date
7 doesn't --

8 MR. LEE: In that general range, yes.

9 MEMBER HORNBERGER: Okay. And so my
10 question -- you talk about -- throughout your talk
11 it's that you want to make this computationally
12 efficient. Okay. Now, over 15 years computational
13 efficiency changes sort of, right, because of computer
14 capabilities.

15 MR. GROSSMAN: Yes.

16 MEMBER HORNBERGER: Okay. So how does
17 that get factored in? I mean, I assume that it gets
18 factored in, that you are now able to do more
19 complicated things and still be efficient. Is that
20 roughly what we're talking about?

21 MR. ESH: We work for the government, so
22 we still have 15-year-old computers.

23 (Laughter.)

24 I think your question is a good one, and
25 I'll answer it.

1 MEMBER HORNBERGER: Okay.

2 MR. ESH: We basically expand to match our
3 computing needs is the answer. We do as much as we
4 can with the new resources, the computational
5 resources that we have.

6 MEMBER HORNBERGER: Yes. I guess, really,
7 there are probably two ways that one could look at it,
8 Dave, and I just don't know how you balance it. I
9 mean, on one hand you might say, well, we would like
10 to use at least part of our increased computational
11 capability to be able to do more realizations, in
12 which case you really are maintaining computational
13 efficiency in the old sense, just so you can do more
14 calculations.

15 On the other hand, you could expand your
16 calculation to do the same number of realizations, but
17 have a more complex code. And I was just curious
18 about what your balance is there.

19 MR. MCCARTIN: Well, I mean, I can go back
20 to when we first developed it, and basically what we
21 wanted to do is have a code that we felt we would be
22 running somewhere on the order of 400 realizations.
23 And we wanted that -- to be able to run that overnight
24 on a Cray and have the results the next day. And so
25 we backed out sort of --

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1 MEMBER HORNBERGER: Now you can run them
2 on a Mac and have them the next hour.

3 (Laughter.)

4 MR. McCARTIN: Well, as it has turned out,
5 we're not too different than that now, in that we
6 still have a code that we can run in approximately a
7 day, except we're running it on a PC rather than a
8 Cray. And I think we always would want to keep in
9 that ballpark frame that -- we don't want to add a
10 module that now, gee, it's going to take us two weeks
11 to get results out. But I think the desire was to
12 have something that got you -- you could run overnight
13 and have results with 400 realizations. But it's on
14 our -- even our laptops now.

15 CHAIRMAN GARRICK: Mike?

16 VICE CHAIRMAN RYAN: Yes, a couple of
17 questions. First of all, I think the improvements are
18 real interesting to track through. I'm curious -- for
19 your major and your minor improvements, have you done
20 any sensitivity studies on how a particular change --
21 are you calculating higher doses, lower doses, better
22 dose numbers? I mean, how does it impact your answers
23 or your ability to interpret the answers?

24 MR. GROSSMAN: In terms of I think digging
25 down to find out specific causes of changes, some of

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1 that went on as development testing occurred. But a
2 lot of that will be coming up in the next year with
3 our performance analyses as we use the code and start
4 to exercise it.

5 VICE CHAIRMAN RYAN: So that's yet to
6 come. And I guess on your other modification slide,
7 19, which I know you thought were minor, I'm curious
8 that the cladding correction factor -- how that works
9 and why that's minor.

10 MR. GROSSMAN: For the cladding
11 correction --

12 VICE CHAIRMAN RYAN: Because, I mean, I
13 would assume that has a big impact on potential
14 release fraction -- release from inventory or
15 something of that sort.

16 MR. ESH: This is Dave Esh. It can have
17 the potential. But as in TPA 4.1, our CLST staff --
18 container life and source term staff -- basically
19 advocated the position of no credit for the cladding.
20 So, but we realize that DOE may take credit for it.
21 In addition, their cladding credit is not one where
22 it's static temporally. So it's not one where you
23 have a certain fraction failed at time zero, and then
24 it stays that way for the whole simulation.

25 VICE CHAIRMAN RYAN: Oh. So you can

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1 handle a temporal difference. Oh, okay. Great.

2 MR. ESH: We have the ability to receive
3 a temporally-changing rate of the cladding failure in
4 case we needed to.

5 VICE CHAIRMAN RYAN: Okay, great. Thanks.

6 CHAIRMAN GARRICK: What is your position
7 on that? Does it continue to be something you're not
8 going to consider, or you are going to consider
9 cladding?

10 MR. ESH: I think you have to talk to our
11 container life and source term people about it.

12 CHAIRMAN GARRICK: I see.

13 MEMBER HORNBERGER: Do you mean you just
14 do what you're told, Dave?

15 (Laughter.)

16 CHAIRMAN GARRICK: This is a performance
17 assessment. It's supposed to be realistically
18 representing what can happen.

19 MR. MCCARTIN: Well, I mean, we will
20 review what the DOE provides in their license
21 application. They'll have to defend any cladding
22 credit, and that's --

23 CHAIRMAN GARRICK: Right. Right.

24 MR. ESH: From a performance assessment
25 standpoint, the cladding gets a lot of discussion.

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1 But some things that are lost in the discussion is
2 that regardless of the cladding that you have in the
3 commercial spent nuclear fuel you still have stainless
4 steel clad fuel, which the stainless steel cladding is
5 not expected to last like the zircalloy cladding.
6 That represents a certain fraction.

7 You have a certain fraction in the
8 commercial spent nuclear fuel that has failed
9 cladding. That's an additional failure that goes in.
10 And then, you do have the glass source term, which
11 represents a waste form that's in the repository.

12 So the ultimate effect of the cladding is
13 not as large as may be expected whenever you do like
14 an on/off type of analysis where you add the cladding
15 in and then you take it back out, because it's not
16 complete protection for all of the fuel.

17 CHAIRMAN GARRICK: Yes, but it's -- the
18 zircalloy clad fuel certainly dominates the
19 inventory.

20 Any other questions? Go ahead, Ruth.

21 MEMBER WEINER: On your slide 16, the one
22 with the RMEI, you indicate that radioactive decay is
23 the only elimination method from the RMEI. Is that a
24 surrogate for physiological -- I mean, there are other
25 ways to eliminate radionuclides from the body other

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1 than just by allowing them to decay.

2 MR. GROSSMAN: The RMEI is eroding --

3 MEMBER WEINER: Oh, he's eroding.

4 (Laughter.)

5 See, I figured that wasn't it. That came
6 out the side.

7 (Laughter.)

8 MR. GROSSMAN: There are other removal
9 mechanisms.

10 MEMBER WEINER: I would encourage you to
11 be a little clearer about that.

12 MR. GROSSMAN: Okay. Point taken. Thank
13 you.

14 CHAIRMAN GARRICK: Questions from staff?
15 Yes, Neil.

16 MR. COLEMAN: Neil Coleman, ACNW staff.
17 In the aftermath of the March working group on
18 TSPA TPA, the committee wrote a letter, and one of the
19 comments was the committee questions the extent to
20 which diffusive transport is the basis for
21 radionuclides to exit a waste package.

22 And if I heard you right, earlier in your
23 talk you mentioned that advective transport still
24 overwhelms the diffusive transport. So that being the
25 case, why spend the resources to put a diffusion model

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1 back in the TPA code?

2 MR. GROSSMAN: Well, at this point, as I
3 discussed, it was thought that since DOE does draw
4 doses in a 10,000-year time period, at least based on
5 the IRSR model from diffusive releases that this would
6 be a way that we could probe that.

7 MR. COLEMAN: But do you think this
8 approach is reasonable? Realistic?

9 MR. GROSSMAN: For that -- I'd have to
10 defer to someone on that.

11 MEMBER HORNBERGER: Chris, wouldn't this
12 be a good example of an answer to Ruth's question --

13 MEMBER WEINER: Yes.

14 MEMBER HORNBERGER: -- the difference
15 between a code for analyzing what DOE does versus
16 compliance.

17 MR. GROSSMAN: Yes, that's true. That's
18 true. It would be.

19 MR. CAMPBELL: This is Andy Campbell. If
20 the Department comes in with a model for LA in which
21 diffusive release dominates the source term within the
22 10,000-year period, we need to have the ability to
23 evaluate that and say, "Do we feel that's a
24 conservative model? Do we feel that's a realistic
25 model? You know, how conservative, how realistic is

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1 it?"

2 So even if at this point in time advective
3 flow would dominate the releases in the TPA code, it
4 really depends on what DOE comes in with, you know.
5 And you're exactly right, this is an example of a
6 regulatory choice of including something that from a
7 purely risk perspective might not have been included
8 normally.

9 CHAIRMAN GARRICK: So this suggested
10 constraint on your code that is a little different
11 than if you were just building a code to do
12 performance assessment. And it is a good example of
13 Ruth's question about what is in your code that is
14 explicitly there for the purpose of being a review
15 tool as opposed to an assessment tool, because if you
16 were going to do a risk assessment based on what you
17 know you probably wouldn't do it that way.

18 MR. CAMPBELL: You probably would have
19 eliminated that somewhere earlier in the process. But
20 given that --

21 CHAIRMAN GARRICK: Yes.

22 MR. CAMPBELL: -- we've seen at least in
23 the past this being part of their, you know,
24 presentations of TSPA SR, it was felt it was important
25 to include that.

1 CHAIRMAN GARRICK: Right.

2 MR. GROSSMAN: And I'd walk back to the
3 planning criteria. The first bullet there is
4 really --

5 CHAIRMAN GARRICK: Yes.

6 MR. GROSSMAN: -- to steal one of your
7 terms, Dr. Garrick, is the 800-pound gorilla.

8 CHAIRMAN GARRICK: Right.

9 MR. GROSSMAN: That will be our job is to
10 review that license application.

11 CHAIRMAN GARRICK: Right. Good. Yes.

12 All right. Any other questions? Comments
13 from staff or anybody?

14 MR. MOHANTY: Just a couple of comments.

15 CHAIRMAN GARRICK: Yes. San Antonio, go
16 ahead.

17 MR. MOHANTY: This is Sitakanta Mohanty
18 from the Center. Dr. Garrick, I would like to address
19 one comment you had made earlier on data updating --
20 updating of the distributions.

21 Either we can use the Bayesian approach or
22 we can use alternative approaches. What we have done
23 so far -- and that work has not been made publicly
24 available yet -- is what we call distributional
25 sensitivity analysis. What Bayesian updating is going

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1 to tell us is whether the distribution function we are
2 using is appropriate or not. It can give us an
3 uncertainty in the distribution function itself.

4 And because the TPA code is used in the
5 Monte Carlo framework, if we bring a PDF uncertainty
6 it is going to significantly increase the number of --
7 perhaps you can render it almost impractical to do it
8 that way. So that is the reason why so far we have
9 taken the approach of conducting distributional
10 sensitivity analysis to find out if that has
11 significant influence on the proponents.

12 CHAIRMAN GARRICK: Thank you. Thank you
13 very much.

14 MEMBER HORNBERGER: See, now I didn't
15 think from my colleague here to my right that there
16 was an alternative to --

17 CHAIRMAN GARRICK: No, there isn't.

18 MEMBER HORNBERGER: -- the Bayesian
19 approach.

20 (Laughter.)

21 CHAIRMAN GARRICK: But we won't get into
22 that.

23 (Laughter.)

24 Any other questions? Andy, go ahead.

25 MR. CAMPBELL: I was just going to add to

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1 something Chris had said earlier is that we're in the
2 process right now working with the Center to develop
3 a -- essentially what we're calling quantitative
4 analysis to address risk issues.

5 And they will consist of sensitivity
6 studies and a variety of other analyses that help us
7 better understand some of the questions that have been
8 raised with respect to risk insights and to evaluate
9 some aspects of the agreements that we're working
10 through that are being submitted by the Department,
11 and that we feel that will lead us into a capability
12 of using the code in an efficient way in the license
13 review.

14 And even though Dave says we have 15-year-
15 old computers, we actually have a slug of brand-new
16 ones in, so --

17 CHAIRMAN GARRICK: No. What he meant is
18 those are 15 years old.

19 (Laughter.)

20 I was going to ask you, Andy, that very
21 question of whether or not this very interesting work
22 that you all are doing to implement the risk
23 initiative -- risk insights initiative, is that having
24 any influence on the basic TPA code? Or are you doing
25 a lot of that offline?

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1 MR. CAMPBELL: Well, a lot of the risk
2 insights come from running the TPA code.

3 CHAIRMAN GARRICK: Right.

4 MR. CAMPBELL: Primarily running the 4.1
5 and earlier versions of the code. There is an
6 extensive report that's either out or about to come
7 out on the sensitivity analyses using 4.1. So what we
8 plan to do is address some specific issues that have
9 come up in the context of developing the final risk
10 insights report.

11 A lot of interaction we've had with the
12 individual KTI staff. People have raised issues
13 about, well, what's the basis for this? What's the
14 basis for that? And through that process, we're going
15 to try and identify some specific analyses that can
16 help nail down some of the issues and questions.

17 And we're also using risk insights in a
18 variety of other areas, trying to evaluate different
19 analysis model reports that DOE has, which of those
20 are the more important ones to look at.

21 CHAIRMAN GARRICK: Yes.

22 MR. CAMPBELL: Which of the agreements are
23 more important to focus our resources on, and so on.
24 So, and even in terms of developing evaluations of
25 DOE, what are the important areas to look at? So it's

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1 -- if you will, it's working its way into the system
2 in a variety of areas. The TPA code provides at least
3 one tool to help us in that process.

4 MEMBER WEINER: Are you using the results
5 from the TPA code to give you some idea of when you're
6 going to stop? When, you know, TPA -- N equals what
7 is the last TPA that you need. Is that driven by risk
8 insights, or what is going to drive that?

9 MR. CAMPBELL: I think realistically that
10 5.0, with some modifications, is going to be the tool
11 we're going to use in the license review, just because
12 of the amount of time for any major changes to be
13 made. And I think -- and correct me if I
14 mischaracterize it -- I think we've incorporated most
15 of the input that we needed to have in the code for
16 that.

17 MR. McCARTIN: Sure. I mean, that's the
18 hope. I mean, obviously we're always subject to, if
19 something new is learned that is dramatically
20 different, we certainly would revise the code if
21 necessary.

22 The only other thing I'd supplement,
23 though, it's a two-way street. I mean, having looked
24 at the risk insights, as people sometimes -- often
25 note that depending on what you don't have in the

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1 code, you can't see sensitivity to it. And so there
2 is modifications being done to the code as a result
3 of, well, yes, you saw that. But if you added this
4 feature, maybe you'd have a different insight. And so
5 it truly is a pretty dynamic process in terms of the
6 iterative cycle. So --

7 CHAIRMAN GARRICK: Okay. Very good.
8 Thank you.

9 We're a little ahead of schedule, and
10 we're going to go into -- unless there was some more
11 on that topic -- there were no more presentations,
12 were there, Andy?

13 MR. CAMPBELL: No.

14 CHAIRMAN GARRICK: No. I think what we'll
15 do is take a 15-minute recess and reconvene and go to
16 the next topic.

17 (Whereupon, at 2:55 p.m., the proceedings
18 in the foregoing matter went off the
19 record.)
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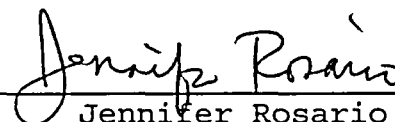
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