ORIGINAL ACNWT-0141

UNITED STATES OF AMERICA

NUCLEAR REGULATORY COMMISSION

Title: ACNW 121ST ADVISORY COMMITTEE (ACNW)

PROCESS USING ADAMS
TEMPLATE: ACRS/ACNW-005

Location: Las Vegas, NV

Date: Wednesday, September 20, 2000

Pages: ~~287~~ 187 - 430

ANN RILEY & ASSOCIATES, LTD.
1025 Connecticut Avenue, NW, Suite 1014
Washington, D.C. 20036
(202) 842-0034

TR08

DISCLAIMER

UNITED STATES NUCLEAR REGULATORY COMMISSION'S

ADVISORY COMMITTEE ON NUCLEAR WASTE

SEPTEMBER 20, 2000

The contents of this transcript of the proceeding of the United States Nuclear Regulatory Commission Advisory Committee on Nuclear Waste, taken on July 27, 2000, as reported herein, is a record of the discussions recorded at the meeting held on the above date.

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

1 UNITED STATES OF AMERICA

2 NUCLEAR REGULATORY COMMISSION

3 ***

4 ADVISORY COMMITTEE ON NUCLEAR WASTE

5 ***

6 121ST ACNW MEETING

7

8 PUBLIC MEETING

9 ***

10 Ballroom B

11 Crowne Plaza Hotel

12 Las Vegas, Nevada

13

14 Wednesday, September 20, 2000

15 The Commission met in open session, pursuant to

16 notice, at 8:00 a.m., B. John Garrick, Chairman, presiding.

17

18 COMMITTEE MEMBERS PRESENT:

19 DR. B. JOHN GARRICK, Chairman, ACNW

20 DR. RAYMOND G. WYMER, Vice Chairman, ACNW

21 MR. MILTON N. LEVENSON, ACNW Member

22 DR. GEORGE HORNBERGER, ACNW Member

23

24

25

1 STAFF AND PARTICIPANTS:
2 DR. JOHN T. LARKINS, Executive Director, ACRS/ACNW
3 MR. HOWARD LARSON, Acting Associated Director, ACRS/ACNW
4 MR. RICHARD K. MAJOR,, ACNW Staff
5 MS. LYNN DEERING, ACNW Staff
6 MR. AMARJIT SINGH, ACNW Staff
7 DR. ANDREW C. CAMPBELL, ACNW Staff
8 JAMES E. LYONS
9 NEIL COLEMAN, NMSS
10 WILLIAM REAMER, NMSS
11 DR. JOHN TRAPP, NMSS
12
13
14
15
16
17
18
19
20
21
22
23
24
25

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

2 [8:00 a.m.]

3 MR. GARRICK: Good morning. The meeting will now
4 come to order. We welcome Jim Lyons, joining us on the
5 staff side of the table, the new Director for Technical
6 Support for the ACRS and ACNW.

7 MR. LYONS: Thank you. I'm glad to be here.

8 MR. GARRICK: Good. This is the second day of the
9 121st meeting of the Advisory Committee on Nuclear Waste.

10 My name is John Garrick, Chairman of the ACNW.
11 Other members of the committee include George Hornberger,
12 Ray Wymer, and Milt Levenson.

13 The entire meeting will be open to the public.

14 Today, the committee will hear a project overview
15 from the Department of Energy; a Department of Energy
16 representative on Yucca Mountain will give a status report
17 on the site recommendation consideration report from DOE;
18 discuss major aspects of the total performance, system
19 performance assessment, the site recommendations version;
20 hear an update on chlorine-36 from DOE and the M&O; discuss
21 the results of ongoing studies on the fluid inclusion issue
22 from a panel composed of representatives of University of
23 Nevada-Las Vegas, DOE, and the state; and, review relevant
24 activities and status of site tour scheduled for tomorrow.

25 We'll also continue to work on preparation for the

1 meeting that the committee has with the Commission,
2 originally scheduled for October 17, now rescheduled for
3 December 18. At that meeting, we intend to discuss such
4 issues as site sufficiency review, risk-informed regulation
5 in NMSS, Part 71, ACNW action plan and priority topics, and
6 we will also discuss the recent trip taken by ACNW to
7 England and France.
8 Andy Campbell is the Designated Federal Official
9 for the initial portion of today's meeting.
10 This meeting is being conducted in accordance with
11 the provisions of the Federal Advisory Committee Act.
12 We have received one request from a member of the
13 public regarding today's session. Mr. Corbin Harney, who
14 spoke to us yesterday, wants a few more moments. I'm
15 suggesting that we maybe do that just before the break this
16 morning. And if others of you wish to make comments, please
17 contact a member of the staff.
18 Also, please use one of the microphones, identify
19 yourself, and speak clearly.
20 Okay. With that, I think we'll jump right into
21 the first presentation. I'm going to ask each of the
22 speakers to introduce themselves, tell us what their
23 positions are and organizations and what have you.
24 MR. DYER: Good morning. I'm Russ Dyer. I'm
25 DOE's Project Manager at Yucca Mountain and I can't tell you

1 what a delight it is to be here this morning. I just
2 finished a three-week detail in Washington, got in last
3 night.
4 Next slide, please.
5 I'm going to give a quick overview. There are
6 about six topics that we're going to go through, look at a
7 little at the project accomplishments over the past year,
8 design evolution, the role of the site recommendation
9 consideration report, the progress that we're making toward
10 the closure of the NRC key technical issues.
11 My understanding is I think that was gone over in
12 considerable detail yesterday, so I'm just going to hit the
13 highlights.
14 Integrated safety management system is an
15 initiative that is going on across the Department of Energy
16 throughout the complex. We are finishing up our last phase
17 validation this week on that. That is something that has
18 taken a lot of energies, just to tell you a little bit about
19 that, and then a quick project outlook, what lies ahead of
20 us here.
21 Next slide, please. Accomplishments. Next slide.
22 If we look at the general schedule of things here,
23 running out through the site recommendation and its
24 associated final environmental impact statement and then
25 further on out to the license application and eventually

1 operations.

2 We have put the draft environmental impact

3 statement on the street. We've had public hearings on that.

4 The next major activity that's called for in the Nuclear

5 Waste Policy Act is the site recommendation.

6 We are putting out a site recommendation

7 consideration report this fall/winter which lays out the

8 technical basis at this point in time to support and

9 underlie that site recommendation decision.

10 Next slide, please.

11 The things that we got done so far in 2000.

12 Underlying the site recommendation consideration report are

13 a series of process level model reports and then below those

14 lie the what are called AMRs, analysis and model reports.

15 I'll show you a diagram in a little while which shows the

16 cascading hierarchy of technical supporting documents, all

17 of which get summarized up into a site recommendation

18 consideration report and then finally built into the site

19 recommendation.

20 There are nine process model reports. We have

21 accepted seven of them unconditionally. The remaining two

22 PMRs have been accepted with conditions. There were 121

23 supporting lower level, more detailed analysis and model

24 reports, 119 of those have been completed.

25 On the design side, the pertinent document there

1 is called an SDD, the system description document. There
2 are 24 of those that lie within our plans. All of those
3 have been -- 24 that are needed to support SRCR. There are
4 others that will be needed eventually to support the license
5 application, and those have a further finer level of detail
6 in the engineering analyses and 34 of those have been
7 completed.
8 If you have been following the repository safety
9 strategy, about a year ago, we determined that we had
10 focused entirely on the post-closure. We needed also to put
11 in a pre-closure element of the repository safety strategy
12 and we've completed a preliminary cut at the pre-closure
13 safety assessment.
14 The total system performance assessment for the
15 site recommendation has been completed. Bob Andrews will
16 talk to you much more about that, and about the base case
17 calculations for the TSPA-SR and the sensitivity
18 calculations that have been completed and are also in
19 progress.
20 Next slide, please.
21 In the testing arena, and Mark Peters will talk to
22 you in considerably more depth about this and we'll see more
23 of it tomorrow, we've started hydraulic testing in the
24 luvium single well pump test, that's been initiated in one
25 of the Nye County holes down in the south of Yucca Mountain.

1 We should start multi-well testing and tracer testing in
2 '02.
3 Within the frost drift hydraulic properties and
4 seepage testing has been initiated in the lower lith, lower
5 lithofizal unit. That's primarily in -- that would be in
6 niche five. The drift-to-drift seepage test is underway in
7 alcove eight.
8 And yesterday, I believe, although I didn't hear
9 confirmation, we turned on a test over at the Atlas
10 facility, over on Locie Road, an engineered barrier system
11 ventilation model test. It's a scale model of surrogate
12 waste packages that have heaters in them and we're looking
13 to validate our models to look at how ventilation can remove
14 heat from that system.
15 And the geo technical investigation of north portal surface
16 facility is underway. This is to provide us more
17 information in the seismic design arena.
18 Next slide, please.
19 Data and software qualification progress. The
20 commitment was that we would have 80 percent of our data and
21 software qualified at the time of the SRCR. We're well on
22 the way there. We're actually over the target with the
23 software qualification. We've got a little bit to go with
24 the data qualification.
25 Our draft rule for the replacement to 10 CFR 960,

1 10 CFR 963, we went through the public hearing process on
2 that. There was a draft final rule that we've submitted to
3 NRC for concurrence back in May and, of course, that's all
4 tied into the 197 and 63 issue.
5 Planning process. Of course, like most -- well,
6 every other DOE agency, we're anxiously awaiting Congress to
7 work on the appropriation. There is supposed to be a
8 conference committee scheduled for today and I'm hopeful
9 that by the end of today, we'll have an idea of what our
10 budget for 2001 will be.
11 Of course, we've done planning based on
12 assumptions. We have a lot of stuff that we would like to
13 do. It does not look like that we will be able to bring in
14 the entire 437.5 million dollars that the Administration
15 requested for the project and the program for this year, but
16 it will be reasonably close, I hope.
17 Of course, that's the caveat at the bottom. We
18 have a lot of plans, but you can only do what you can afford
19 to do.
20 Next slide.
21 Design evolution. The design has evolved somewhat
22 since the EDA-2 design of a couple of years ago. One of the
23 major changes is as we looked at the waste stream inventory
24 coming in, the waste stream, in general, is somewhat hotter
25 because there's higher burn-up fuel as part of the waste

1 stream.

2 Whenever we reevaluated the heat that was in the
3 system, of course, one of the requirements that we have on
4 the system is a maximum 350 degree Centigrade centerline
5 temperature in the waste packages, so that the cladding is
6 not subjected to unzipping.

7 And when we looked at the effects of the blanket,
8 the thermal blanket that would be put in if you put in
9 backfill, it looked like we would violate that.

10 So part of the exercise that we've done over the
11 past year is looking at updating the design to remove the
12 backfill, which, of course, gives you a system which then
13 could be ventilated for a considerable period of time.

14 This is just a schematic of what we're looking at
15 now with, again, the horizontal cylinders emplaced on
16 pylons. We now have a drip shield that is part of the
17 system. The drip shield is of titanium, a titanium alloy.

18 The material for the waste package is still a
19 nickel alloy corrosion resistant material on the outside,
20 with, I believe, a stainless steel, essentially a structural
21 material on the inside.

22 Other things, we've gone away from a concrete
23 lining in the emplacement drifts which we had several years
24 ago. Right now, the ground support is just structural
25 steel.

1 Next slide, please.

2 The design, of course, has not been static,
3 continues to design, continues to evolve. Looking at the
4 underground, there are a couple of variables that we can
5 play with reasonably simply. Whenever we talk about design,
6 it's really a combination of design and operational
7 parameters that you can look at juggling.

8 For instance, you can take the same design, that
9 is, waste package design, the same emplacement drift
10 specifications as far as diameter spacing, ground support
11 that you use, and you can operate that system in different
12 ways by either varying the spacing between the waste
13 packages, so tailoring the line thermal load within the
14 emplacement drifts, or by using combinations of active and
15 passive ventilation for various periods of time, you can
16 adjust and control how much heat the system will put into
17 the rock mass.

18 That's been, as you're undoubtedly aware, an issue
19 that the Nuclear Waste Technical Review Board, for one, has
20 been concerned about. It's also one that the U.S.
21 Geological Survey expressed concern about in the Director's
22 review of the viability assessment a couple of years ago.

23 So looking at different ways that one can approach
24 the management of heat in the system is something that we're
25 doing now.

1 The current reference design has moved the
2 emplacement drifts somewhat further apart, about twice as
3 far apart, about 81 meters apart, and would allow the rock
4 mass, the drift walls to heat up above boiling for some
5 distance away from the surface of the emplacement drifts,
6 perhaps maybe ten to 15 meters.
7 And looking at what it takes if we were to try to
8 bring this whole system to a below boiling design, we're
9 still evaluating what it would take to do that and what you
10 would gain from such a change.
11 Next slide, please.
12 TSPA-SR, the TSPA to support the site
13 recommendation, will incorporate the no backfill reference
14 design in the base case analysis. That's a change that
15 we're moving to, and I believe that either Bob or Abe will
16 talk about some of this, looking at the sensitivity studies
17 that are associated with that.
18 We will -- the current plan is to maintain the
19 reference design, an above boiling operational mode and
20 design is the base case, and look at sensitivity analysis
21 from the TSPA to try to understand what are the pros and
22 cons of various approaches.
23 Next slide, please.
24 The site recommendation consideration report.
25 This is not a pitch for pyramid power or anything, but it is

1 an attempt to try to lay out, at least graphically, the
2 hierarchical structure of the thing that sits at the top,
3 which is eventually a national action, the Secretary's
4 action, and then the supporting documents that make up part
5 of the package that go to these higher levels, the Secretary
6 and the President, to support a decision.
7 The site recommendation consideration report
8 currently consists of two volumes. Volume I is an update of
9 what we know and how TSPA works. Volume II is a preliminary
10 suitability evaluation.
11 Eventually, the full site recommendation must have
12 many other things in it that are called out by law,
13 including comments from the state and affected counties and
14 Native American Indian tribes.
15 Sitting below these two volumes of the site
16 recommendation consideration report are what we would call
17 the technical basis report. I talked earlier about the
18 PMRs, the nine process model reports, and then below those
19 nine PMRs, there are, I believe, it's 122 of the analysis
20 and modeling reports, the engineering analysis.
21 All of that makes up hundreds of thousands of
22 pages of reference material that is referenced or pointed to
23 by these higher level documents.
24 Our intent has been to try to put this together in
25 an integrated manner. The way we chose to do this is we're

1 going for a web-based approach on this, with hypertext
2 links. So one could go to a document and eventually be able
3 to go from a citation in the document, directly plunge down
4 into the reference citation. It's going to take us a while,
5 I think, to get to that.
6 Next slide, please.
7 The role of the site recommendation consideration
8 report. It is not a document that is called for by
9 legislation. But the Nuclear Waste Policy Act does call for
10 the DOE to hold public hearings to receive residents'
11 comments on DOE's consideration of a possible site
12 recommendation action.
13 And we wanted to put something reasonably recent,
14 the last big document we had was the viability assessment,
15 we wanted to put something reasonably recent on the street
16 that could inform this dialogue and comments for the public
17 hearings, and that's where the site -- the idea for the site
18 recommendation consideration report came from.
19 We are still on schedule for releasing it in late
20 2000. The intent is to summarize the technical basis and to
21 facilitate the public review and comment process.
22 The technical basis documents, all the bottom of
23 the pyramid, almost all of that is going to also form the
24 technical basis for the license application. So we have
25 encouraged certainly the Nuclear Regulatory Commission, as

1 they are looking at the basis for sufficiency comments on
2 the body of work that DOE has done, to not confine
3 themselves to just looking at the SRCR, but to also look at
4 the other documents, the PMRs, the AMRs, and down to the
5 individual lower level reports.
6 Next slide, please.
7 And that was a proposal that we proposed to the
8 NRC back November of last year. NRC agreed in principal to
9 this proposed approach. So far, we've provided seven of the
10 nine PMRs to the NRC staff and 119 of the 121 supporting
11 AMRs, and 11 of the SDDs have been provided.
12 Some of the documents that we have currently in
13 review within DOE, the TSPA Rev. 0 and the Yucca Mountain
14 site description, an update of that. So we will get those,
15 I hope, on the street here within the next four to six weeks
16 and those will also support this technical basis that we're
17 building.
18 Next slide, please.
19 Progress toward closure of NRC KTIs.
20 Next slide.
21 We've had three meetings, each on one of the KTI
22 areas, since August, got a couple more planned. I know that
23 we've got five more that we need to get planned. Those have
24 been -- I'm very encouraged by the progress on those. We've
25 been able to either close or close pending virtually every

1 issue that has been put up, which means that between the
2 information knowledge that's known now and the plans that
3 are provided essentially as a promissory note for things
4 that will be done over the next period of time before the
5 license application, those have been acceptable to NRC staff
6 as a reasonable path forward.
7 Of course, there is no guarantee that the answers
8 that you get and work that has not been done yet is going to
9 turn out the way you think it will now.
10 Next slide, please.
11 The sub-issues. As I said, this has allowed us to
12 take almost all of the sub-issues that were examined in the
13 three meetings to date and either close them or close them
14 pending. The agreements that have been reached help us
15 define a path forward for issue closure and we're -- my
16 understanding is that we proposed dates for the technical
17 exchange on the remaining KTIs. The intent, of course, is
18 to get those done.
19 I think the last meeting that we have scheduled is
20 February on TSPA, if I remember right, and the intent is to
21 get everything in hand well before that date.
22 Next slide, please.
23 Integrated safety management system, and this is a
24 very large effort within the Department of Energy, and it is
25 an attempt to bring what I would call disciplined process

1 and integrated management across the entire spectrum of
2 things that DOE is involved in.
3 Instead of just having nuclear quality assurance
4 and nuclear safety and having a different culture and a
5 different program for other aspects of safety, the intent is
6 to bring one safety system umbrella over all that goes on
7 within the department.
8 For years, within the department, we have been
9 sort of victimized by a series of almost independent
10 programs that have competed for resources, rather than
11 putting a single program in place that really helps you
12 define across the whole spectrum of your programs,
13 everything that's going on; helps you prioritize it, helps
14 you identify where the safety risks are, and dedicated
15 appropriate resources to the most important things.
16 So this has been a very good exercise for us and
17 we are in the last phases of that and I would hope by the
18 end of this week we'll be able to put our name on the wall
19 and say that we are moving forward in this. This is not a
20 one-time endeavor, however. It's one of these things that
21 is based on the concept of continuous improvement. So once
22 you have essentially your basic system in place, the charge
23 and challenge is to continue to improve that system year
24 after year after year.
25 Next slide, please.

1 Phase one verification. We had no discrepancies.
2 We had six opportunities for improvement. Those are listed
3 here. One noteworthy practice, the worker involvement. The
4 workers, especially at the site, have really embraced this
5 program and have made it the success that it is.
6 When told that they could stop work if they
7 thought that there was an unsafe environment or a lack of
8 adequate planning prior to implementing some activity, this
9 really energized them and they have assumed absolute
10 ownership of this program.
11 It's great and you will see that tomorrow, I
12 think. You will see the pride and the ownership of the
13 safety program on the part of everybody who works on the
14 program.
15 The phase two verification, the way it breaks out,
16 phase one is that you have the paper in place. Phase two is
17 that you can demonstrate that you are implementing the
18 program that's on that paper.
19 So the phase two was completed back in July. We
20 are currently in the middle of -- I'm sorry -- the phase one
21 completed back in July. Phase two, we're currently in the
22 middle of that activity right now and should get that report
23 from an independent review team this week.
24 Next slide, please.
25 Well, the big thing looming on the horizon,

1 funding uncertainty. The appropriation, as I said, has not
2 been set. We are holding our fingers to see what comes out
3 of conference committee today.
4 There is a considerable discrepancy between the
5 marks that the House took into the conference and the
6 Senate. The Administration request was 437.5 million. The
7 House marked 413, the Senate marked 351. So probably it's
8 going to be -- the final mark will be somewhere between 351
9 and 413, I would hope much closer to 413, but any of those
10 marks is considerably below the mark that the Administration
11 supported.
12 As we prioritize the work for the next physical
13 year and coming physical years, that work supporting the
14 site recommendation schedule has the highest priority and
15 what we told the appropriators and the Congressmen was that
16 at lower funding levels, the site recommendation schedule
17 may be at risk.
18 The schedule for licensing milestones is
19 uncertain. Of course, our highest priority is for the site
20 recommendation work, and what that does to the work that's
21 needed to meet these commitments that we're making as part
22 of the KTI resolution meetings remains to be seen. Some of
23 those may be stretched out in time somewhat.
24 Next slide, please.
25 The SRCR and the technical basis documents below

1 it continues to have almost all of our energy put into it.
2 There's an enormous amount of work that has been done to put
3 together this integrated effort.
4 We learned an awful lot in the viability
5 assessment effort and trying to put things together, put the
6 defensible basis together, and make sure that there was
7 consistency through all of the program.
8 But translating those lessons learned into firm
9 accomplishments has taken a lot of energy. We're putting a
10 high priority, obviously, on the interactions to close the
11 KTIs and to support the NRC sufficiency review.
12 Looking forward to better understand the
13 sufficiency review process, of course, we're waiting, as
14 most people are, for 10 CFR 63, 963 and 197 to hit the
15 street.
16 The same caveat about funding limitations applies
17 here. Actually, I think this is almost exactly the same
18 thing we said on the last slide. Depending on the funding
19 level, the SR schedule may be at risk and, of course, it can
20 impact everything downstream from that, including the LA.
21 Next slide, please. And I believe I've gone
22 through my last slide here.
23 So let me, if we have time, I'd be happy to answer
24 any questions, Mr. Chairman.
25 MR. GARRICK: Thank you. Would you be willing to

1 comment on the things that would have to happen for the
2 design to stop evolving?
3 MR. DYER: Stop evolving.
4 MR. GARRICK: Or to fix the design.
5 MR. DYER: Even if we were to select, say, a point
6 design concept, design is an evolutionary thing and I can't
7 imagine it stopping, per se.
8 MR. GARRICK: What I'm getting at is there is
9 obviously, in the minds of the experts, some things that
10 you're looking to achieve, some things that have to happen
11 before you feel comfortable with the design. We keep
12 talking about evolving design. As a matter of fact, the
13 National Academy of Sciences recommended many years ago in
14 their re-thinking report that you remain flexible, that we
15 remain a little more flexible in the way in which we're
16 going to manage the high level waste, up closer to the time
17 that we have to really do something.
18 But nevertheless, there comes a point beyond which
19 you have to make decisions. You have to make that decision
20 about the design that you're going with.
21 And I guess what I'm asking, from a design
22 standpoint, not necessarily from a regulatory standpoint,
23 but from your own requirements standpoint, what are some of
24 the key things that you think have to happen in order for
25 you to be happy with the design?

1 MR. DYER: If we look at the requirements that a
2 design must satisfy, first, making clear what those
3 requirements are, there are technical performance criteria
4 that must be built in, but there are other criteria that may
5 revolve around economics, they may revolve around I'll call
6 it technical credibility.
7 And some of those we're having a hard time putting
8 our arms around those about how hard and fast those should
9 be as requirements, how do you build those into a
10 requirements document, which you normally thought of as
11 pretty much performance specifications.
12 But there are other considerations that may be
13 just as important as those hard and fast performance
14 specifications. But that's an area that we're exploring
15 right now. A program that is technically immaculate, that
16 costs hundreds of billions of dollars is probably not very
17 useful for this country.
18 What's the tradeoff between a program that
19 adequately protects health and safety of the public and the
20 workers and a program that the nation can afford and
21 support?
22 I suspect I didn't answer your question, because
23 I'm not all together sure that I know or that anybody knows
24 what the right answer is.
25 MR. GARRICK: What I was getting at is where the

1 focus of attention is. Sometimes I think in the
2 preoccupation with the regulatory milestones and the various
3 reports that you have established as goals, it obscures some
4 of the understanding of what's going on in fact with the
5 design in terms of what really is important to safety.
6 Now, we'll get into this more with the performance
7 assessment, of course, but, also, I think that people, after
8 you've spent three-plus billion dollars, are beginning to
9 think that the time ought to be getting close to when a
10 design ought to be surfacing that you're quite comfortable
11 with or if you're not comfortable with it, you have a pretty
12 darn good idea of what it is that it's going to take to meet
13 these fundamental requirements of safety and performance.
14 I was just pushing that a little bit in terms of
15 what were the main issues from the perspective of the
16 project manager.
17 Any questions? Milt, have you got any questions?
18 MR. LEVENSON: No.
19 MR. GARRICK: Ray?
20 MR. HORNBERGER: Yes. Russ, if your budget does
21 come in at, let's say, 413 million, will the SRCR be
22 released in calendar year 2000?
23 MR. DYER: That's our current intent, yes.
24 MR. HORNBERGER: So when you mentioned it might be
25 winter 2001, that was under a budget constraint scenario.

1 MR. DYER: Yes. That would be a fairly strong
2 budget, constrained budget.
3 MR. HORNBERGER: So for the NRC, you're still
4 looking for May of '01 to have the comments back.
5 MR. DYER: I think that's right. I believe --
6 yes. Right now, we haven't changed anything in the way of
7 our interactions. That's what the KTI meetings have been
8 geared for and that is our preferred path.
9 MR. HORNBERGER: Also, just one small
10 clarification, if you can clarify for me on the technical
11 exchanges. Of course, you held the one on the unsaturated
12 zone in Berkeley, I believe, and you have one coming up in
13 Albuquerque on the saturated zone.
14 And your little footnote said that unsaturated
15 flow is also covered in the saturated zone flow. Is this
16 just a follow-up from the unsaturated KTI or is there some
17 part of the unsaturated zone flow that gets lumped into the
18 saturated zone?
19 MR. DYER: I'm going to get some help here. I
20 thought they were lumped together and we just treated them
21 separately.
22 MS. HANLON: There are two aspects of that, Dr.
23 Hornberger. There are two aspects of that. First of all,
24 the unsaturated zone in Berkeley did not include the matrix
25 flow for the saturated zone. So that part will be moved

1 forward to Albuquerque.

2 The second thing is we will be discussing our

3 evaluation of additional information on infiltration

4 regarding the unsaturated zone in Albuquerque and how we're

5 going to proceed forward to hopefully clothespin that item.

6 So those are the two things that are put forward.

7 MR. HORNBERGER: Thank you.

8 MR. GARRICK: Any questions from the staff?

9 [No response.]

10 MR. GARRICK: Thank you very much, Russ. Very

11 good.

12 MR. DYER: My pleasure.

13 MR. GARRICK: Our next presentation will be on the

14 site recommendation consideration report. It says here

15 Steve Brokoum, but you don't look like him.

16 MR. SULLIVAN: No. You have Tim Sullivan instead.

17 Good morning.

18 MR. GARRICK: Good morning.

19 MR. SULLIVAN: Actually, this will be a two-part

20 presentation. When I'm done, Carol Hanlon will give you a

21 brief overview, from DOE's perspective, of the sufficiency

22 interactions that have been conducted to date.

23 I'm the Team Leader for the Site Regulatory

24 Products, including the site recommendation.

25 This is an outline of what I'm going to discuss

1 here. I'm going to focus here mostly on the contents of
2 Volume II of the SRCR and I will explain why in a moment,
3 and then some further schedule information. Some of this is
4 redundant with what Russ has presented, so I'll move over
5 those parts quickly.
6 Current status. The report itself is in DOE
7 review and it's on schedule for release in late 2000,
8 calendar year 2000.
9 An overview of the contents of the site
10 recommendation consideration report. Volume I of the two
11 volume report was built around the requirements of the
12 Nuclear Waste Policy Act, Section 114(a)(1), which requires
13 three things; a description of the proposed repository, a
14 description of the waste form and packaging, and a
15 discussion of the data relating to the safety of the site.
16 So on the next slide, the Volume I is organized as
17 follows. It includes, in addition to the information I just
18 referred to, as a part of Section 4, the discussion of the
19 data relating to the safety of the site. It includes
20 TSPA-SR results. It also includes a section on pr-closure
21 safety assessment. Both of those support Volume II.
22 And then Volume II itself -- Volume I will be
23 similar in form and content to the viability assessment;
24 that is, it is descriptive material and analytical results.
25 Volume II is somewhat different in that here, DOE

1 will make a preliminary evaluation of suitability in
2 accordance with the proposed 963 siting guidelines.
3 So Volume II is, in fact, organized around the
4 proposed regulation. Now, I'm going to spend a few minutes
5 describing to you what the contents of that volume are.
6 It's actually three parts. The first is an
7 introduction, the second is the preliminary pre-closure
8 suitability evaluation, includes a description of the
9 assessment approach used to achieve safe operations before
10 closure of the repository, and it will also include a
11 discussion of the suitability criteria identified in the
12 regulation.
13 The focus here is to ensure that the repository
14 systems limit releases and that we have adequate emergency
15 planning systems in place or response systems in place.
16 Then Section 3 is the preliminary post-closure
17 suitability evaluation. Here, the proposed rule includes
18 requirements for the TSPA methodology that I will describe.
19 It calls for DOE to identify natural and engineered features
20 important to isolating waste, and we will do so.
21 There are a series of suitability criteria or
22 characteristics that I will describe. And, finally, it has
23 release limits to which we will compare the TSPA results for
24 the 10,000 year compliance period.
25 So, first, I'm going to describe in a little more

1 detail Section 2 and then Section 3.

2 So in Volume II, Section 2, the pre-closure

3 methodology, the approach that we're taking is to apply

4 established nuclear technologies, proven technologies, and

5 using those technologies and established methods for design

6 and operations; that is, accepted codes and standards.

7 The assessment approach itself, fundamentally, is

8 to reduce releases to workers and to the environment.

9 The approach starts with a systematic

10 identification of events based on standard hazard

11 evaluations. It then follows with a screening or a

12 determination of which events apply to the systems that will

13 be built at Yucca Mountain and then, finally, these events

14 are categorized into category one or category two, depending

15 on their associated probabilities.

16 Then the consequence analysis is complete, the

17 preliminary consequence analyses are reported. These

18 determine the dose for comparison with the limits specified

19 in the regulation.

20 Finally, the repository design establishes

21 criteria for the prevention and mitigation of repository --

22 repository design establishes criteria for the use of

23 features and controls important to safety. These are, of

24 course, to prevent and mitigate consequences.

25 Now, the suitability criteria in the regulation,

1 page eight, in these sections, DOE must demonstrate the
2 ability to contain radioactive material and limit releases
3 of radioactive materials.
4 Here, the burden is on DOE to demonstrate that the
5 radiation doses are below the limits.
6 Secondly, to implement control and emergency
7 systems to limit exposure to radiation. Again, DOE will
8 describe the preliminary program for the emergency systems
9 and this program will rely on industry standards and proven
10 technologies.
11 Ability to maintain a system and components that
12 perform their intended safety functions. In this section of
13 Volume II, we will record analyses of structures, systems
14 and components to ensure that they are performing as
15 intended.
16 And, finally, the system design will ensure the
17 option for retrieval up to 300 years.
18 In Volume II, the preliminary post-closure
19 suitability evaluation. Part 963 has a series of
20 requirements for the TSPA methodology that will be used to
21 assess post-closure performance for the 10,000 year
22 compliance period. These requirements are that data related
23 to the post-closure suitability criteria or characteristics
24 are incorporated in the TSPA, and I will describe those
25 characteristics in a moment.

1 The methodology also must account for
2 uncertainties both in information and in modeling. It must
3 demonstrate that alternative models have been considered and
4 in Volume II, we will summarize the consideration of
5 alternative models in the TSPA-SR, in the PMRs, and in
6 Volume I.
7 It must provide the technical bases for input
8 parameters, for the FEPS analyses, the features, events and
9 processes analyses, and for the models used or abstracted
10 into the TSPA.
11 Finally, the TSPA must conduct appropriate
12 sensitivity studies. So Volume II will address each of
13 these requirements for the TSPA methodology, on page 10.
14 The rule also calls for DOE to identify the
15 natural and engineered features that are important to
16 isolating waste and we will do so. Six natural and
17 engineered features will be described. These are summarized
18 from the barrier importance analyses that are in the TSPA-SR
19 that Bob and Abe will describe in a moment.
20 First is surficial soils and topography, reduce
21 the amount of water entering the unsaturated zone for
22 surficial processes, infiltration is less than
23 precipitation.
24 Unsaturated rock layers overlying the repository
25 and host rock unit reduce the amount of water reaching the

1 repository. Here, seepage is less than percolation.
2 Drip shield and inverts surrounding the waste
3 packages. The drip shield that Russ described, the titanium
4 drip shield protects the waste package from any seepage that
5 may enter the drift and there is a ballast placed in the
6 invert below the waste package in the bottom of the tunnel
7 that serves to limit advective transport into the host rock.
8 On page 11, the waste package prevents water from
9 contacting the waste form for thousands of years based on
10 the corrosion resistant material that's been selected and
11 the corrosion testing that the department has completed to
12 date.
13 The spent nuclear fuel cladding delays or limits
14 the water from contacting the actual fuel pellets.
15 Finally, the waste form itself serves to limit the
16 contact of water with the nuclear fuel itself, both in the
17 commercial and the DOE high level waste glass form.
18 Each of these will be described in Volume II of
19 the SRCR.
20 Okay. Another requirement of the rule is for DOE
21 to evaluate a series of suitability criteria or
22 characteristics. There are a total of nine here. These
23 closely parallel the process model reports that the
24 department has prepared to support the TSPA-SR and Volume II
25 of the SRCR.

1 For each of these characteristics, Volume II will
2 describe the technical basis -- that is, the data -- that's
3 used in this evaluation. It will describe the models and it
4 will include a regulatory evaluation of how this information
5 is represented and incorporated in the TSPA-SR and will do
6 so for each of these post-closure suitability criteria.
7 On page 13, similarly, disruptive events will be
8 evaluated as suitability criteria, also. Then, finally, in
9 Volume II, the results of the total system performance will
10 be evaluated.
11 The methodology described and the criteria will be
12 evaluated -- will be used for a preliminary evaluation of
13 the suitability of the site. This is done by comparing the
14 release standards to the TSPA-SR does results both for the
15 pre-closure and the post-closure requirements.
16 You've seen page 15 before. The only point here
17 is that I'm going to briefly describe the technical basis
18 documents, some of which Russ has already described.
19 I want to emphasize here that we have assembled
20 the site recommendation consideration report such that it is
21 fully traceable to the underlying technical basis documents.
22 By that, I mean, specifically, that no new information, per
23 se, is presented in the site recommendation consideration
24 report. Everything that is presented and summarized in that
25 report is fully traceable to the technical basis

1 documentation that you see in the pink and the purple areas
2 of this pyramid.
3 Page 16, Russ mentioned the analysis and modeling
4 reports used to document the analyses and models of
5 individual FEPS using site characterization data sets. They
6 cover both the natural and engineered features of the site.
7 The PMRs then synthesize and integrate groups of
8 AMRs to describe and model general categories of features
9 important to post-closure repository performance.
10 They serve as an intermediate level, the
11 equivalent of the TSPA-VA technical basis document, in which
12 the component models for the TSPA were described.
13 The SDDs are the engineering analyses to document
14 surface, sub-surface and waste package designs, and then the
15 TSPA-SR uses abstracted results from AMRs to analyze the
16 performance of the repository with a focus on a 10,000 year
17 compliance period, but it presents results for longer time
18 periods, as well.
19 Page 17, I think we've been over this. On page
20 18, I provide the current status of the PMRs, the process
21 model reports. In fact, they've all been now accepted as
22 Rev. 0 by DOE. However, further updates and modifications
23 to the process model reports are underway in the final
24 column.
25 There are two main drivers. The first is that we

1 are -- the M&O is now completing the revisions to AMRs to
2 incorporate the no backfill design that Russ described and
3 those final updates are underway now and they will result in
4 updates to the PMRs between now and December.
5 And number two, based on internal comments, the FEPS AMRs,
6 the features, events and processes AMRs, and there is one
7 for each of the PMRs except the integrated site model, based
8 on internal comments, those are also being revised and
9 updated and those results will also be incorporated in the
10 PMRs that will be available at the time of the release of
11 the SRCR.
12 You will also note here, on the right, that full
13 revisions of two of the PMRs are underway, the UZ PMR and
14 the engineered barrier system PMR.
15 We will have, though, at the time of the release
16 of the SRCR, all of these PMRs in their final form
17 available.
18 Page 19, additional technical basis documents.
19 The preliminary pre-closure safety evaluation is a report
20 that's been prepared to support our preliminary evaluation
21 in Volume II of the SRCR. It's an analysis of the
22 radiological safety for a repository at Yucca Mountain.
23 The site description is a comprehensive compendium
24 of site information, including chapters on natural resources
25 and natural analog studies.

1 The repository safety strategy, which will soon be
2 in Revision 4, is a general plan for the identification and
3 prioritization of the factors important to repository system
4 performance and it formulates a safety case where DOE will
5 present the essential aspects of the performance of a
6 repository system.
7 On page 20, I just want to make a couple points
8 here. The first is that the process that we have used to
9 assemble the TSPA-SR and the SRCR includes a foundation
10 built on the left side of AMRs and PMRs, some of which, as I
11 mentioned, are being updated, in the red box, to reflect the
12 no backfill design and those support the TSPA-SR and the
13 SRCR.
14 We'll go through a similar process and we'll do another
15 update to the TSPA in the spring and we'll go through the
16 same process again of updating and revising AMRs and then
17 PMRs to develop a subsequent iteration of the performance
18 assessment for the license application.
19 There are a couple of new boxes in here. In light
20 green, you'll note the FY-00 technical update. This is a
21 report that the department will also release at the time of
22 the SRCR. Its intent here is to provide an update on
23 testing and design work that has occurred subsequent to the
24 freezing of the inputs for the TSPA-SR to provide all
25 interested parties the most current information that we can.

1 And we are currently contemplating another such
2 document for the time of the SR currently scheduled for July
3 of '01 to, again, provide as current information as possible
4 to support these documents.
5 On the next page, page 21, DOE has developed the
6 site recommendation consideration report to inform the
7 public of the technical basis for the consideration of the
8 repository at Yucca Mountain and to facilitate the public
9 comments during the SR consideration hearings. It's to
10 promote the dialogue.
11 The SR, the site recommendation, that will follow
12 will provide a comprehensive statement of the basis of any
13 recommendation that the Secretary will make to the
14 President. It will include additional information as
15 required by the Nuclear Waste Policy Act.
16 It will include the views and comments of the
17 governor and legislature of any state or the governing body
18 of any affected Indian tribe, together with the response of
19 the Secretary to such views.
20 It will include, on page 22, the preliminary
21 sufficiency comments from the NRC. Carol will discuss that
22 a little further in a moment. It will include a final
23 environmental impact statement, any impact reports submitted
24 to the department by the State of Nevada, and any other
25 information that the Secretary considers appropriate.

1 On page 23, the act does require that the
2 Secretary hold public hearings in the vicinity of Yucca
3 Mountain for the purpose of informing the residents of the
4 area of such consideration and receiving their comments
5 regarding the possible recommendation.
6 Current planning calls for these hearings in early
7 2001. Location and number of the hearings has not yet been
8 determined.
9 Finally, here on the schedule chart, I won't go
10 through each milestone, but I will identify several key
11 ones. The first star there in late 2000 represents the
12 release of the SRCR. The vertical red dashed lines and the
13 horizontal arrow identify the comment period. Our current
14 planning is for 90 days. And subsequent to that, the gray
15 star would represent receipt of the NRC sufficiency
16 comments, Secretarial decision on whether to proceed with
17 the site recommendation in June, and then DOE will submit
18 the SR to the President in July of '01, waiting 30 days
19 after notification to the state of the Secretarial decision,
20 a minimum of 30 days.
21 On the bottom are some EIS milestones which
22 culminate in the submittal of the FEIS to the President at
23 the same time as the SR and its subparts.
24 So that's all I had to present this morning. I
25 could entertain questions now or we could have Carol do her

1 piece and have questions later. I'll leave that to you.
2 MR. GARRICK: Let me ask the committee. Are there
3 any questions?
4 MR. WYMER: I have one sort of a general
5 off-the-wall question. This is going to be a large and
6 comprehensive document with a lot of stuff.
7 MR. SULLIVAN: About 1,300 pages.
8 MR. WYMER: Who will review this thing? It seems
9 that most of the people in the country who are competent to
10 review it have been involved in the preparation of it.
11 Do you have any idea how this thing will be
12 reviewed and where will they find the people to do this?
13 MR. SULLIVAN: Well, I can't speak to that
14 specifically. It will be accompanied by an overview, which
15 is a much slimmer document, similar to the VA overview. We
16 have targeted the SRCR to a general audience. We have tried
17 to make develop the document so that it will be
18 understandable to people who are not expert in individual
19 disciplines of engineering or science.
20 MR. WYMER: But you have no feeling on that, and I
21 don't really know why you should have, but you have no
22 feeling of who actually will do the review, where they will
23 get the people from.
24 MR. SULLIVAN: DOE has received 11,000 comments on
25 the DEIS. So we expect people will review and comment on

1 portions or the entire document.

2 MR. WYMER: So it's just people.

3 MR. SULLIVAN: Stakeholder organizations and

4 individuals, interest groups of various kinds.

5 MR. WYMER: But the President, in quotes, is the

6 person to actually say this looks like it's the real stuff

7 and it will work, so let's go ahead.

8 MR. SULLIVAN: Right. First the Secretary, then

9 the President.

10 MR. WYMER: So somebody has to advise him.

11 MR. SULLIVAN: Right.

12 MR. WYMER: And it will not be the public.

13 MR. SULLIVAN: It will be the Secretary.

14 MR. WYMER: Okay.

15 MR. SULLIVAN: Taking into account all of the

16 comments that have been received on the document and the

17 views of the affected governors and legislatures and the

18 preliminary sufficiency comments of the NRC.

19 MR. WYMER: So it's kind of a closed loop here.

20 Okay.

21 MR. HORNBERGER: Tim, in your pre-closure

22 comments, you mentioned that retrievability would be assured

23 for up to 300 years.

24 MR. SULLIVAN: Correct.

25 MR. HORNBERGER: So I take it you're still holding

1 to, what, a 50 to 300 year possibility for pre-closure.
2 MR. SULLIVAN: Yes. We identify the period up to
3 300 years as the period in which the repository potentially
4 could be monitored and we would have decommissioned the
5 surface facilities and entered into a monitoring phase.
6 But we would have retained the -- not the
7 possibility -- we have retained the capability to retrieve
8 the waste up to 300 years, meaning we would maintain the
9 ground support within the repository and if and when needed,
10 we would commission surface facilities to handle the waste
11 retrieval.
12 MR. HORNBERGER: And then your analysis also then
13 includes the possibility of a tunnel collapse and things
14 like this and still have the capability to retrieve.
15 MR. SULLIVAN: Yes. You will see degradation
16 analyses in the SRCR and in the supporting documents.
17 MR. GARRICK: Any other comments? Staff?
18 MR. LARKINS: A quick question. Yesterday, we
19 heard from a representative of the State of Nevada who
20 discussed how his views on the importance of the performance
21 confirmation plan and DOE strategy, and we didn't hear any
22 mention of it this morning. Is this a part of your -- how
23 doe the PCP fit into this?
24 MR. SULLIVAN: We will describe, and I omitted
25 that, the performance confirmation plan in the SRCR and

1 there is a plan, a stand-alone report, that will be
2 available also. So that was an oversight on my part.
3 MR. GARRICK: Thank you. Thank you very much.
4 Carol?
5 MS. HANLON: Perhaps if I just begin my
6 presentation, and Andy will go ahead and he will adjust it
7 and you can hold up your hand if you don't hear.
8 You will notice that we spent a good portion of
9 this meeting discussing different portions of the key
10 technical issues, technical exchanges. I think that that's
11 an aspect that warrants a good deal of emphasis.
12 I appreciate the presentations that we had
13 yesterday from the Nuclear Regulatory Commission, Bill
14 Reamer, John Trapp and Neil Coleman I think did an excellent
15 job of setting the stage and identifying some of the things
16 that have gone on to date and discussing for us the path
17 forward that we've looked at.
18 I would like to discuss a few of those things from
19 the Department of Energy's perspective to clear a couple
20 areas I think that remain perhaps not fully understood, to
21 help you all with your understanding of our document and
22 perhaps understand Dr. Wymer's question a bit more on review
23 and how the reviews are going.
24 One of the things I'm going to talk about is I'm
25 going to talk about process for these meetings, what we're

1 looking for, what we're going to do with upcoming meetings,
2 and also how we're handling the agreements on items that
3 have come out of the meetings, the technical exchanges that
4 we've previously had and will continue to come out, because
5 there will be agreement items and we're watching those very
6 closely.
7 So as Tim and Dr. Dyer have both said, we have a
8 requirement from the Nuclear Waste Policy Act that we
9 provide sufficiency comments. We include sufficiency
10 comments provided to us by the Nuclear Regulatory Commission
11 as part of our site recommendation and those are in two
12 important areas, at depth site characterization, waste form
13 proposal, and I think the words that they are sufficient,
14 they appear to be sufficient for inclusion in any
15 application to be submitted.
16 That's an important concept. That's a
17 forward-looking concept and it helps us focus on where we're
18 at with regard to the site recommendation consideration
19 report, the SR and forward to the LA.
20 So obviously to the Nuclear Regulatory Commission
21 staff, a very important portion of their sufficiency review
22 has been the resolution of their key technical issues,
23 non-key technical issues, and those have been documented in
24 the issue resolution status reports.
25 Our purpose, our goal is that the technical

1 exchanges will result in a clear understanding of the status
2 of each of these and where there is not resolution, a path
3 forward for reaching resolution.
4 The first general kind of overarching technical
5 exchange was held April 25 and 26 in Nevada. That had a
6 dual purpose; first, the purpose of discussing how
7 sufficiency would be approached and, secondly, to discuss in
8 full the status, both perceived by the Commission and as
9 perceived by the department, with the new information that
10 we had as we were preparing analysis and modeling reports
11 and we were preparing the process model reports and going
12 forward to the total system performance assessment, what our
13 reflection of the status was.
14 Based on that, we subsequently set up a series of
15 technical exchanges on specific topics. Now, this is where
16 a bit of the unclarity, I think, still remains for your
17 committee and I would like to just take the opportunity to
18 clarify that a bit.
19 You will recall the November 24 letter from Dr.
20 Brokoum to John Greeves and in that letter, we proposed an
21 approach for providing additional information which would
22 support the Commission's ability to review our technical
23 basis documents and make sufficiency comments.
24 Based on that, we had suggested a series of
25 meetings, specifically nine meetings, focused on process

1 model reports. You've heard a good deal this morning on
2 process model reports, analysis and modeling reports and
3 other documents, both from Dr. Dyer and from Tim, and it
4 perhaps is a bit daunting.
5 Our approach in setting up these meetings was to
6 discuss the particular category of a process model report,
7 the analysis and modeling reports that contributed to that,
8 the impact to the total system performance assessment, and,
9 of course, very importantly, the contribution to the
10 specific key technical issue that was addressed by that
11 process model report.
12 To make our series of meetings and our technical
13 exchanges more effective, we adjusted that approach and I
14 think that may be something that was a bit confusing and
15 left you all a bit in a lurch on that.
16 We are now focused specifically on the key
17 technical issues and that's so that we can very specifically
18 take that same information, the process model reports, the
19 AMR reports, the portions of the TSPA, and address it very
20 specifically to an individual key technical issue.
21 So on this, you will see the set that you had
22 previously seen, I think that we did this schedule in late
23 July and you've seen it since then.
24 I briefed you, I believe, in July on this. And
25 that includes our completed unsaturated zone technical

1 exchange in Berkeley. The igneous activity, also completed,
2 was held in Las Vegas, and the container life and source
3 term that were completed last week in Las Vegas.
4 Two that you're still familiar with are the
5 structural deformation and seismicity technical exchange
6 that will be held the week of October 11, actually the 11th
7 through the 13th, and saturated zone flow, as we mentioned
8 this morning, will be held in Albuquerque.
9 We've added an additional day to that. It's
10 October 31st, November 1st and 2nd. I also might just make
11 another comment, to make sure that we have ample and
12 adequate information for full discussion, full vetting of
13 the issues and full presentations, basically we have three
14 days for all of these technical exchanges.
15 In order to facilitate the Commission's ability to
16 do their sufficiency review and have their comments ready,
17 as we've asked them, in by the end of May, the Commission
18 asked us to go forward in setting up the series of meetings
19 on remaining key technical issues and to try and have those
20 done by the end of January.
21 We moved out in February a bit, but I think we're
22 pretty close. These have not been fully agreed to with the
23 Commission staff yet, but I have put months down here so
24 that you can see what remains before us and get an idea not
25 only of our busy schedule, but consequently, I think, your

1 busy schedule.

2 The in-package criticality, which is subissue five
3 of the container life and source term, will be held October.
4 It's actually, I think, October 24 to 26, as it is currently
5 scheduled.

6 In November, we will have the technical exchange
7 on thermal effects on flow. December we'll have the
8 technical exchange on radionuclide transport.

9 Also, in December, we have identified the
10 possibility of a briefing on the total system performance
11 assessment results, since we had previously had the meeting
12 in June in San Antonio. Now that the TSPA will be coming
13 out, there is a potential that there will be a briefing on
14 that, not solidified yet.

15 In January, we will have two meetings; earlier
16 January, evolution of near field environment; later January,
17 the repository design, thermal mechanical effects. And the
18 last meeting, the 6th through 8th of February, is the total
19 system performance assessment integration.

20 So that's our new set and when we have the
21 formally agreed to list of meetings, we'll make sure that
22 you get a copy of that.

23 You've heard quite a lot about the status of these
24 meetings and I just want to recap for you a bit. The three
25 meetings we've had are unsaturated zone flow. The number of

1 subissues with regard to that were five. The sixth one will
2 be handled, as we've said, at the saturated zone in
3 Albuquerque. That's on matrix flow in the saturated zone.
4 From that KTI technical exchange, we have four
5 issues which were closed -- subissues, excuse me, which were
6 closed or closed pending and one remains open. That is on
7 the infiltration and that came up in some of the discussions
8 yesterday.
9 There was some information, new information from
10 the center that was presented during the technical exchange
11 in Berkeley that our staff had not had the chance to fully
12 evaluate. So what we have come up with is, regarding that
13 subissue, a proposal to evaluate that new information and
14 identify what we do need to include and what would explain
15 or justify what we may not think is relevant.
16 So that's the approach that we are going to
17 present to the saturated zone. If you have any specific
18 questions, we have Martha Pendleton here, who can talk to
19 the specifics of the infiltration.
20 Another issue that came out of that unsaturated
21 zone flow meeting was the discussion of the importance of
22 fully understanding the subsystems as you are also
23 understanding the performance of the entire system.
24 I think that's had a little bit of confusion here.
25 The point is not that because of a very strong component in

1 this case, a long-lived waste package, you're unable to
2 understand the subsystems. The point is that in order to
3 understand the full system, we must understand all the
4 components, we must understand all the portions of the
5 subsystem, the natural system, the engineered system.
6 So our particularly strong portions should not
7 obscure the issue nor should it be a penalizing component,
8 but we must understand fully all of those. That's what we
9 are committed to doing.
10 Bob Andrews, in his discussion of total system
11 performance assessment, is going to go into a bit more of
12 exactly how we take those subsystems, full understand them,
13 as we move forward to an understanding of the total system.
14 With regard to igneous activity, we had two issues
15 there. One is closed, one is open. I included our score
16 card, and so did John. This is actually we're a little
17 better than that, we're about 90 percent closed on the
18 subissue for consequences and the reason we're not fully
19 closed on that is that we have some AMRs that will be
20 completed late this year, this calendar year, and provided
21 to the Nuclear Regulatory Commission, addressing the no
22 backfill issue, and it was believed that to fully be able to
23 understand the consequences and close that issue, they
24 needed those AMRs.
25 We fully agree with them and we're making every

1 effort to move forward to get those AMRs and they will be in
2 their hands in January.
3 Container life and source term, we had six issues,
4 we've closed five. The issue, subissue we did not close was
5 not addressed in this particular technical exchange. It's
6 the issue of criticality and it will be addressed in a few
7 weeks at the second CLST meeting in October.
8 It's not in my handout, but one of the things I
9 did want to mention to you is that as you can see, and I've
10 tried to create a complete record here, you can move through
11 a few of these, John, so that you can see what the title is,
12 what the status is, and what the agreements are.
13 Now, it's very important, as we make these
14 agreements, to track them very clearly and make sure that we
15 get the exact information back to the Commission on
16 schedule, as we've promised.
17 An example of that comes again from the
18 unsaturated zone meeting in Berkeley, where the Commission
19 staff asked to see a copy of the test plans for Alcove 8.
20 We committed to providing those within a week.
21 We did provide them within a week. Neil Coleman
22 made sure that the review occurred and he's got our comments
23 back. So those agreements have been handled. We are now in
24 the process of evaluating those and seeing if there are
25 modifications that we can make to our test plan to

1 accommodate the comments we received from the NRC.

2 To make sure these things are happening, we are

3 tracking them very closely, both formally and less formally.

4 I won't say informally. We have a condition identification

5 reporting and resolution system, which is a formal system

6 that's in place, and that's a system, it's important for you

7 to know that that is in place and it will transition as we

8 go through the period of having a new contractor.

9 So these agreements on the items regarding the

10 closed pending will not be lost. They are in a formal

11 tracking system and they will transition.

12 Also, on an operating basis, to make sure that we

13 are staying very much on top of this, we've instituted

14 weekly or biweekly briefings on the status of items that are

15 coming out of these and where they remain and where we are

16 with regard to providing information to the Commission.

17 So we are watching those very closely. Another

18 one that's much on our mind is the infiltration issue that's

19 coming up for the saturated zone.

20 I think we can probably move forward, leaving you

21 with these things to review at your leisure. I think we can

22 move forward to 14.

23 From our standpoint, the department has spent a

24 great deal of effort on these. We understand and appreciate

25 the effort, also, that the Commission staff has dedicated to

1 these technical exchanges. We feel that they have been
2 extremely productive.
3 The three meetings only have resulted in four
4 subissues changed from open to closed pendings. Four
5 subissues I've discussed remain open, and two of those
6 subissues were not addressed in the interactions. They were
7 the saturated zone and the criticality. So we are moving
8 forward.
9 We believe that these technical exchanges have
10 been extremely effective in establishing either the status
11 or the path forward to a closure status.
12 I feel that our teams are working closely and very
13 well together. There's a good exchange of information and
14 that's very productive, I think, to working toward providing
15 the Commission with the information that we believe they
16 will need. And the management commitment, both by the
17 department and the Commission staff, has certainly been a
18 definite asset.
19 So we're continuing to hold and move forward with
20 these technical exchanges, supporting the staff's approach.
21 We were a bit disappointed that we weren't able to year the
22 Yucca Mountain review plan approach and that the formal
23 sufficiency approach. We're concerned that we really are
24 definitely on target and that we're not missing something
25 that the Commission will need.

1 So the sooner that we can know those specific
2 details and know that we are on target, we can move forward
3 or we can adjust our path as we need to.
4 So we'd like to confirm the path that we're
5 currently engaged in and moving forward to both creating
6 information that will be sufficient for the license
7 application docketing and, also, the sufficiency comments
8 that the NRC will provide.
9 May I answer any questions for you?
10 MR. GARRICK: Any questions? John, you have a
11 question?
12 MR. LARKINS: I was just curious. What happened
13 to the biosphere PMR technical exchange?
14 MS. HANLON: That was included in the igneous
15 exchange, John. That was very much a part of the second day
16 of the igneous activities exchange.
17 MR. LARKINS: Has that been combined now?
18 MS. HANLON: It's been completed. It was the
19 second one that was completed.
20 I believe John Trapp, Dr. Trapp spoke about it
21 yesterday. It was believed that in order to fully
22 understand those components of the igneous activity, the
23 dose consequences and so forth, that the biosphere aspects
24 had to be brought in.
25 So I think we had either a half-day or a full day.

1 MR. LARKINS: Because there was a previously
2 scheduled separate technical exchange and we had committed
3 to have somebody participate, but I didn't realize it had
4 been combined with the igneous activity.
5 MS. HANLON: Dr. Hines was there, so you did have
6 support there. And I hope that in this I've been able to
7 partially explain Dr. Wymer's question about who and how is
8 this review going to be done.
9 There is a great volume of information and Dr.
10 Dyer spoke about it a bit in our hyperlink text system on
11 the internet.
12 So if you have a specific question, hopefully
13 we'll be able to click on that and go down through that.
14 But these meetings are -- we are attempting to set them up
15 so that we are explaining the technical basis that's
16 supporting various aspects of our TSPA, of the site
17 recommendation consideration report, and specifically
18 focusing them on the KTIs.
19 So hopefully that's assisting the review somewhat.
20 MR. WYMER: Well, I had naively assumed that there
21 would be some sort of independent initial review, but that
22 isn't going to happen.
23 MR. GARRICK: I guess just to extend that thought
24 a little bit, the committee was quite impressed with the
25 reports that were prepared by the peer review group that was

1 put together by DOE on the TSPA and I just wondered if that
2 particular model was going to be applied to any of these
3 other key reports.
4 MS. HANLON: I don't think we've implemented at
5 this time, but we certainly can keep that in mind.
6 MR. GARRICK: George, you had a question.
7 MR. HORNBERGER: Carol, these technical exchanges,
8 and now that you have some experience with them, obviously
9 take an awful lot of effort, involve an awful lot of work.
10 I gather, however, even given your experience, you're
11 confident that the very ambitious schedule you have you're
12 going to hold to.
13 That is, you haven't fallen behind in any of this
14 as a result of having the ones that you've had.
15 MS. HANLON: We're doing pretty well so far and
16 you are right, Dr. Hornberger, it takes a tremendous amount
17 of effort, both on the part of the Commission staff and the
18 center and the part of DOE and our supporters.
19 So they are extraordinarily intensive. However,
20 we've done pretty well in staying on target. We've looked
21 at things carefully. The Commission has been extremely good
22 if something needs to be moved and we've also tried to
23 accommodate needs that they may have had to move a meeting.
24 But we're shooting for this target and I'm very
25 optimistic about it. We did leave ourselves Christmas and

1 New Year and we managed to leave ourselves Thanksgiving.
2 If there are no other questions.
3 MR. GARRICK: Any other questions? I want to
4 thank you for presenting an excellent scorecard for a very
5 complex process. That's very helpful.
6 MS. HANLON: You're certainly welcome. Thank you.
7 MR. GARRICK: Okay. I think that in spite of the
8 fact that a break is not noted in the program and if this
9 goes into the Federal Register, I'm going to accept the risk
10 of violating that piece of information, and declare a
11 15-minute break.
12 [Recess.]
13 MR. GARRICK: Let's come to order. We're not
14 going to turn our attention to the often referred to total
15 system performance assessment site recommendation.
16 I think, Abe, you're going to lead this off, is
17 that correct?
18 MR. VAN LUIK: Last week, I had a reminder that as
19 we become more effective in life, we take on more risk. My
20 oldest grandchild got his driver's license last week and my
21 youngest grandchild decided she could have a better life
22 without diapers, and I'm happy to report that in the ensuing
23 five days for both of them, neither one has had an accident.
24 I'm Abe Van Luik. I'm the Senior Policy Advisor
25 for Performance Assessment and I'm going to give you a short

1 introduction to the TSPA-SR, and Bob will give you the
2 details under the heavy lifting.
3 I wanted to talk a little bit about the regulatory
4 requirements that we're addressing right at this moment, the
5 objectives of the TSPA, summary of the major improvements
6 since the viability assessment, mention a little bit about
7 the barrier design and the basis for process models.
8 If you look at the regulatory requirements, you
9 know that we have proposed regulations on the street right
10 now, and to make this talk very short, what we are doing is
11 addressing all of the nuances of the proposed regulations
12 from EPA, NRC and DOE.
13 When these are finalized, they will become simpler
14 because the NRC will incorporate the final provisions of the
15 EPA and we will not have basically dual nuances on
16 definitions of our MEIs and that kind of thing.
17 If we look at the individual protection or dose,
18 which is the primary performance measure that we are
19 concerned with, we have to include probable behavior, as
20 well as potentially disruptive events.
21 If we look at the objectives, they have changed
22 over the years. TSPA-91, for example, was just to show that
23 we could do one. In '93, we began to get serious about
24 using TSPA to align the project, to look at what's important
25 and what's not.

1 TSPA-95 and the viability assessment got stronger
2 in that department and then TSPA-SR is to support the
3 national decision-making process.
4 TSPA integrates underlying models of individual
5 process components. We're looking at several performance
6 measures, individual dose, ground water protection, the
7 human intrusion standard, and peak dose for the final
8 environmental impact statement.
9 We are looking at the significance of the
10 uncertainty in the process models and Bob will talk a little
11 bit about some of that evaluation process.
12 Major improvements. We've had both technical and
13 process improvements. The process improvements, I think,
14 are easily underestimated in terms of the effort that they
15 have taken. But everything is under quality assurance
16 procedures at this point.
17 We are using the analysis and model reports that
18 Russ Dyer talked about as the thing from which we trace our
19 data and the information flow.
20 We have explicit evaluation, a comprehensive
21 evaluation of features, events and processes. We are using
22 traceable data sets and the TSPA model itself can be used to
23 move down into the data sets themselves, and we are tracking
24 the quality status of all data, models and software.
25 Technical improvements. Some of you mentioned a

1 while ago, I think it was John mentioned that we did have a
2 review on the viability assessment.
3 That review, of course, came after the completion
4 of the viability assessment. So the TSPA-SR and the TSPA-LA
5 will be where we respond to that review in terms of
6 improving our modeling.
7 Models with major enhancements, looking at those
8 comments, and also comments from others, such as the NRC, in
9 the exchanges, as you've heard Carol talk about, of course,
10 we have learned a lot from the NRC about what their
11 expectations are and some of these improvements also address
12 those.
13 But climate and seepage has been greatly improved.
14 A couple thermal processes are lot farther along than they
15 were in the VA.
16 Waste package degradation, we're looking at stress
17 corrosion cracking and initial defects in the welds.
18 Saturated zone transfer and volcanism, all of these models
19 have seen major enhancements since VA.
20 The engineered barrier. TSPA-SR is based on the
21 site recommendation design, no longer the VA design. We're
22 looking at an average thermal load of 62 metric tons of
23 heavy metal per acre, which is lower than the viability
24 assessment. We're looking at at least 50 years of
25 ventilation, it may be more. This is some of the

1 operational mode adjustments that Russ was talking about.
2 We're looking at blending of fuel at the surface
3 to levelize the thermal load.
4 The engineered barrier design considers the
5 titanium drip shield, non backfill, waste packages placed
6 end to end, an average line load of 1.4 kilowatts per meter.
7 The waste package itself, still 21 pressurized
8 water reactor assemblies or 44 BWR assemblies, and
9 co-disposal of Defense spent nuclear fuel and Defense high
10 level waste.
11 The outer layers, alloy-22, 20 millimeters of it;
12 the inner layer, stainless steel, 100 millimeters. The
13 inner layer of stainless steel is not taken credit for in
14 the TSPA. It is a member that gives structural support to
15 the waste package.
16 There is a dual alloy-22 lid closure weld. The
17 outer lid closure weld, the stress is mitigated by solution
18 annealing. The inner lid closure weld, the stress is
19 mitigated by laser peening. These turn out to be very
20 important to long-term performance.
21 This is just a listing of the process model
22 categories and the process model report. On the right are
23 ones that were mentioned by Russ in his talk and, of course,
24 some of these reports, like the near-field environment and
25 the EBS degradation flow and transport reports come into one

1 basket when it comes to the actual modeling, which is the
2 engineered barrier system environment.
3 I don't think I need to spend any time on this.
4 It's just I may make the boast that this is the best
5 integrated performance assessment we have ever done.
6 In the past, you could find principal
7 investigators that said, well, I handed the data over to PA,
8 but I don't know what they did with it.
9 This is no longer the case. The principal
10 investigators are intimately involved in taking their data,
11 abstracting it and putting it into the total system
12 performance assessment.
13 So we've come a long way since the '93-'95 days.
14 An issue that we have to be aware of is that we
15 have to have some statement of how confident we are in
16 whether or not these results that we come up with are useful
17 in the decision-making process. Demonstrating confidence
18 requires a lot of things, but it requires showing a
19 sufficient understanding of processes, determining system
20 behavior.
21 Carol mentioned this in her talk just a few
22 minutes ago, that the NRC staff is very concerned that we
23 show that we understand the processes that we're putting
24 into our modeling.
25 Systematic applications of the features, events

1 and processes, screening. It's a way to show completeness
2 of the arguments, that there's not something big out there
3 that you've just completely forgotten about. This is
4 another way of showing that you have a reason to have
5 confidence.
6 Systematic evaluation of component process models
7 and their importance. You can have a haphazard evaluation
8 and do some neat calculations that say, oh, look how
9 important this is, but a systematic evaluation is what's
10 important to building confidence.
11 And you have to show that you have properly
12 incorporated the important uncertainties. And, of course,
13 the TSPA, as your documentation, has the challenge to make
14 these points clearly and traceably, and in my review of that
15 document, I find that it's a very good read. It's a good
16 document and it's well on its way to illustrating these
17 points quite nicely.
18 Happily, the NRC staff and we see things the same
19 way when it comes to a risk-informed performance-based
20 approach, and I think some of the success that Carol was
21 talking about in having issues closed pending, the delivery
22 of the final products so they can verify that we actually
23 did what we said we're doing.
24 Some of that is based on them and us agreeing that
25 some things are more important than others. Risk-informed

1 means that the entire uncertainty distribution, not just
2 mean value lines, are being used to inform.
3 Performance-based means that the outcome is -- you know,
4 whether a feature or a system or a process is important to
5 swinging the outcome one way or the other, is an important
6 criteria for judging performance.
7 And, of course, something that -- as a corollary
8 to that is something that we mentioned on the previous page.
9 You also have to show that you understand what you're
10 talking about, because if you don't understand it and model
11 it wrong, then your conclusions here don't mean much.
12 So all of these things are together to give us
13 confidence.
14 We use these types of considerations to prioritize
15 science, engineering, design and modeling, and if the budget
16 comes in lower than we would like it to, we will invoke
17 these types of results to say, well, this is more important
18 than that and adjust the funding for science and engineering
19 accordingly.
20 And we also use these considerations to rank key
21 technical issues and decide on the level of effort to be
22 devoted to address them and I think on this, we are in synch
23 with the NRC staff. They agree that this is the right thing
24 to do.
25 The thing that we have to do is to make decisions,

1 even in the modeling of this system, in the face of
2 uncertainty. The basic rules that we have applied so far is
3 that where something is extremely complex or the quantity of
4 data is just insufficient to develop a meaningful
5 distribution, that we take a conservative or a bounding
6 approach.
7 We have several coordinated activities underway
8 now to evaluate how these decisions, which were made as part
9 of the process of creating the TSPA-SR, affects the actual
10 performance measure of dose.
11 We are looking at unquantified uncertainties and
12 these are the conservative values I talked about in the
13 first bullet or, in some cases, maybe even optimistic
14 values. This is in the eye of the beholder or the reviewer,
15 in some cases.
16 We are identifying those and then we will do a
17 trial study, coming up with a distribution for that
18 parameter and running sensitivity studies to see how
19 important it was to have assumed that, or should we go to a
20 more detailed approach.
21 On the next page, we are also, at the same time,
22 looking at the quantified uncertainties, the ones that are
23 documented with data distributions, CDFs, et cetera, which
24 are sampled into TSPA. And we're looking at the
25 uncertainties that were considered at each modeling level

1 and to get a better feeling for just how uncertainty has
2 been rolled up, how well or how poorly it has been rolled
3 up, all the way from the data interpretation process level
4 modeling into the TSPA.
5 And depending on the outcome of these activities,
6 a given activity may be expanded or a new activity defined.
7 This is work in progress, in other words.
8 The goal is to increase understanding of the basis
9 for the TSPA results and improve the basis for judging if
10 there is an appropriate level of confidence for the current
11 stage of the societal decision-making process.
12 The current status of TSPA-SR analyses, and some
13 of you may not believe this, but some of the results
14 presented today are preliminary and subject to change. We
15 are still in checking and this got a chuckle at the
16 technical review board meeting from some people saying,
17 yeah, sure, you're just saying that.
18 But you will see in what Bob presents that some of
19 the curves have changed since the TRB because of the
20 checking process. This is serious. You are seeing draft
21 material that is still being worked.
22 And so they are certainly not suitable at this
23 time for making regulatory compliance judgments. They are
24 intended to be used right here, right now, for general
25 discussions of sensitivities.

1 The calculations that you're seeing are going into
2 Revision 00 of the technical report. The repository safety
3 strategy Revision 04, which is also in draft right now, and
4 the SRCR. We expect to make minor updates, not major
5 revampings, of all of these calculations for TSPA-SR
6 Revision 01, which is coming in next spring, which will
7 support the site recommendation and the final environmental
8 impact statement.
9 So you're seeing a work that's close to being done
10 for one stage and then there will be another smaller stage
11 for the SR, and then we have not looked in this presentation
12 to the LA.
13 And, of course, you'll want to save your questions
14 for Bob Andrews, who is now going to show you the technical
15 side of things.
16 MR. GARRICK: Committee? Milt, go ahead.
17 MR. LEVENSON: I've got a couple of questions.
18 One has to do with I suppose you could define it as a
19 decision-making process. As you go through here, items are
20 either included or you decided to leave them out, like not
21 taking any credit for the stainless steel canister, et
22 cetera.
23 Whether it's to include something or to leave it
24 out, at what level, who makes those decisions? How much
25 review is done of whether you should include something in

1 the TSPA or not include it?

2 This has nothing to do with the technical part of

3 how you treat it, but who decides, in essence, the scope?

4 MR. VAN LUIK: That's a good question. I think

5 there is a process that's not as well defined as you might

6 think it is, but it's in the process model TSPA abstraction

7 interactions where it's actually decided that there's enough

8 information to go forward with this, to bound this, or to

9 say, for the sake of conservatism, we will not take credit

10 for this, although it has a definite purpose, which is to

11 maintain the integrity of the waste package.

12 So these types of decisions are documented in the

13 AMRs that describe the abstraction process, for example, and

14 in some cases, they are documented in the analysis and model

15 reports for the particular example you're talking about, for

16 the waste package lifetime, where it was discussed that,

17 yes, you can get credit for hundreds, maybe even thousands

18 of years, but because of the way that the system is

19 functioning now, this does not really add much except in the

20 terms of the doses of two, 300,000 years out, when it would

21 not perturb things at all.

22 So it's all documented, but the decisions were

23 made, in some cases, at a lower level, at some cases at the

24 abstraction level, and in some cases, DOE might walk in and

25 say do this differently.

1 So it's a decision process we're all made aware
2 of, but it happens at different levels, but hopefully it's
3 our intent that all of these decisions are documented in the
4 AMRs and then rolled up into the PMRs.
5 MR. LEVENSON: They may be documented, but are
6 they carried forward in evaluations such as uncertainties,
7 because it seems to me they could have a significant impact,
8 particularly things that are left out.
9 MR. VAN LUIK: The task that I'm very well aware
10 of, because I'm part of the DOE oversight of it, on the
11 uncertainty evaluations that I was describing, these are
12 some of the issues that we're looking at; should we have
13 done what we did or should we bite the bullet and go into
14 more detail in the modeling of this particular issue.
15 So it's definitely one that we will address in
16 that process, but that's still work in progress.
17 MR. LEVENSON: In the consideration of
18 uncertainties, are they all treated equal? I mean, some
19 uncertainties are symmetrical or something is plus or minus.
20 In other cases, uncertainty is all plus or all minus.
21 In looking at the overall uncertainties, are
22 things being carried with a sign as well as a quantity?
23 MR. VAN LUIK: This is actually the topic being
24 addressed by our uncertainty task, because what we did at
25 the beginning is we put out some general guidelines on how

1 to treat uncertainties. What we're doing now is verifying
2 whether those were followed or not and we're finding, in
3 some cases, that what you're describing is basically a
4 judgment on what the degree and sign of the uncertainty is,
5 that it was not done. So we're going back to fix those
6 types of things.
7 But in every case, the analysts thought that they
8 were making a conservative assumption, except in one or two
9 cases. Some other analysts disagreed with them.
10 So we are getting at the bottom of those types of
11 things. But I think this should not be confused with the
12 idea that we did not capture what we know are the major
13 causes of uncertainty and I think those are very well
14 wrapped up in this TSPA.
15 So we're looking at something that's a second
16 order correction, basically.
17 MR. LEVENSON: One other question, and I'm not
18 sure you're the appropriate one to ask, but you're standing
19 there. One of the very, very useful outputs of the work
20 you're doing here, but I'm not sure it's being done, and
21 that is the design has been evolving over the last, say,
22 couple of years, a fair amount of time and money has been
23 spent on the design evolution.
24 The TSPA could tell you, probably better than
25 almost any other method, how effective those design

1 improvements have been or are they improvements, do they
2 really reduce dose to the public at the end.
3 Do you have any feel for how much change in the
4 dose to the public has occurred because of so-called design
5 improvements?
6 MR. VAN LUIK: We have done considerable work in
7 sensitivity analyses, a few of which Bob will show in a few
8 minutes, after I sit down. But the basic point is my answer
9 would be yes, we have a very intimate relationship with the
10 designers and we evaluate what they do in those terms.
11 However, there's other things besides dose. There
12 is defense-in-depth considerations. There's considerations
13 of confidence. So because there is uncertainty in the
14 modeling, we also do things like add a drip shield that the
15 TSPA shows that for 10,000 years, since the waste package is
16 intact with or without a drip shield, the dose comes out
17 about the same. It's not exactly the same.
18 But there is another consideration. Do you have
19 defense-in-depth? Do you have reliance on only one barrier?
20 That drip shield gives us two barriers. When you take away
21 one or the other, as you will see when the repository safety
22 strategy four is issued and also you will see in TSPA-SR
23 documentation, you will get the feel that there is actually
24 some backup in this system and that you can have confidence
25 that even though have uncertainty here, that 10,000 year

1 dose number is a pretty good number.

2 MR. GARRICK: Ray?

3 MR. WYMER: No.

4 MR. GARRICK: George?

5 MR. HORNBERGER: Again, just a quick follow-up on
6 Milt's question. Have you done a catalog? We're talking
7 about these bounding values or conservative values or on-off
8 switches. Do you have a catalog? Can you give us an idea
9 of how many of them you have to deal with? Is it ten, is it
10 100, is it 1,000?

11 MR. VAN LUIK: I think it's over 100. We have an
12 initial catalog, but this is work in progress. And so it
13 may expand and it may decrease when we see that we have
14 double-counted some items.

15 MR. GARRICK: Abe, this is a process question and
16 it is an extension of Milt's question. It's one I will lay
17 out that we may come back to with the other presenters. But
18 I want to get it out on the table.

19 We're seeing a lot of language now about
20 quantifiable and non-quantifiable uncertainties. It's
21 language that's also popped up on the nuclear power plant
22 risk assessment world.

23 And I think that it's a situation where there is a
24 great deal of opportunity, it seems to me, for a lot of
25 mischief and I'd like to be enlightened a little bit more on

1 the whole issue of non-quantifiable uncertainties.

2 You say that the way you're handling these, for

3 the most part, is to take point estimates and take and use

4 conservative values or bounding values or whatever, and, of

5 course, part of Milt's question and George's question is

6 some sort of a taxonomy of the impact of these

7 non-quantifiable uncertainties and how they, in the

8 aggregate and through the propagation process, impact the

9 overall credibility of the analysis.

10 But the whole concept bothers me a little bit,

11 because it's a little bit contrary to the notion of what we

12 mean by quantitative risk assessment. Not that you can

13 quantify things that you can't quantify, but the whole

14 thrust of doing a risk assessment is not the manipulation of

15 statistics and information nearly so much as it is

16 establishing the logic between what you're trying to

17 calculate, which might be an event frequency, about which

18 you may have no information, the logic between that and a

19 level at which you do have information.

20 Then the thrust of the evaluation, the review is

21 on the credibility of that logic, not so much the

22 credibility of an unquantifiable piece of information.

23 So I'm just wondering, the way we got around this

24 a lot in the nuclear power risk models was to spend a great

25 deal of time establishing that logic and that, in essence,

1 became the focus of the creativeness, if you would, of the
2 risk assessment as opposed to what often comes up on
3 people's minds when they think of a risk assessment as being
4 a game of statistics.
5 I've said many times, statistics may be five
6 percent of a risk assessment, but it's not a very big part
7 of it. The real effort is in establishing the answer to the
8 question what can go wrong and what characterizes the logic
9 of things going wrong.
10 Are you doing anything specifically to get to these
11 non-quantifiable contributions to uncertainty of that
12 nature? Are you really -- to me, that's what the
13 breakthrough of risk assessment was all about.
14 The rest of it is old technology, came about by
15 way of reliability analysis and general modeling. What's
16 really creative and the aspect of risk assessment that
17 constitutes a major step forward is this modeling process or
18 this logic development process that you go through in going
19 from what you want to learn about, about which you have
20 nothing, down to something that you have good information on
21 and you clearly understand the connection between that and
22 what you're interested in.
23 Isn't that the way to address non-quantifiable
24 uncertainties and are you doing that? You don't have to
25 answer that completely now.

1 MR. VAN LUIK: I can give you a partial answer.
2 We're very well aware of this issue and that's why I
3 mentioned we have a long list of candidates. What we want
4 to do is with some outside expert help, pick out the most
5 likely importance items, perhaps half a dozen to start with
6 out of that list, and say, well, if we have that uncertainty
7 quantified in stead of bounded at this point, what would
8 that buy us.
9 And what we'll do is for that six or maybe eight
10 items, we are talking about invoking an expert elicitation
11 process, with people who would have a feel for this subject
12 from the outside, as well as one or two from the inside and
13 establishing a PDF for that particular parameter or modeling
14 option, and then looking at the importance to the outcome
15 from that and then depending on -- and that's why I said,
16 you know, depending on the outcome of that, if that shows,
17 whoa, this is a bigger thing that we originally thought it
18 was, then we'll move on to the next five or six and by the
19 time of licensing, we should have a much more solid story.
20 But this is something that will take time and it's
21 a sizeable investment. We're aware of the issue and this is
22 the approach that we're piecemeal putting into place for
23 dealing with the issue.
24 MR. GARRICK: Thank you. Any other comments?
25 Yes, Milt.

1 MR. LEVENSON: I have sort of a follow-on question
2 to George's about this catalog of things left out and are
3 bounding.
4 Is it possible to get a copy of that list,
5 recognizing that it's much more fragile and work in
6 progress, but just to get a -- at the moment, I find that I
7 have no real feel for the scope of this issue and it's a
8 fairly important part of the credibility of the TSPA.
9 MR. VAN LUIK: The TSPA-SR document itself, when
10 it comes out, will have a list in it of places where we use
11 conservative assumptions and that's the starting list and
12 that's a pretty short list.
13 In the meantime, some of our other people have dug
14 way into the hinterlands of the process models and the data
15 interpretation reports and come up with a much longer list.
16 The principal investigators looking at these
17 things feel that that's -- the one approach may be a little
18 bit short, the other approach is a little bit overboard.
19 But you will see the very first version when the
20 TSPA-SR document comes through the DOE review and becomes
21 available to you.
22 MR. LEVENSON: That will include lists of all of
23 the things left out, like the stainless steel in the
24 container, et cetera.
25 MR. VAN LUIK: Those kinds of things are the more

1 obvious ones and they will be discussed in the document,
2 yes. But I'm talking about where we use the bounding value
3 rather than a PDF, because our internal expert judgment was
4 that to go beyond that, since we already know that it makes
5 very little difference to the performance measure of
6 interest, would be money not well spent.
7 So those kinds of analyses also will be reflected
8 in that table in the TSPA-SR, and then you go to the AMRs
9 and PMRs and see what the actual logic was.
10 So that is pretty well in there. It's pulling all
11 that together and we have several different people doing it,
12 coming up with different lists, and our job, our task
13 force's job is to come up with one list that we all agree
14 on.
15 But as soon as it's a little bit less flaky than
16 it is now, you can have it.
17 MR. GARRICK: Okay. Andy?
18 MR. CAMPBELL: It sounds like what you're focusing
19 on, though, are parameters, where you're not sure what the
20 range ought to be, so the analyst picks a value that they
21 believe bounds what that range of values would be.
22 And in that analysis that you're doing, are you
23 going to also look at what the shape of the distribution
24 might be on the results in terms of that parameter? That's
25 one question.

1 But more importantly, how are you going to factor
2 conceptual model uncertainty, because you're dealing with
3 parameter uncertainty in that case, but you also have the
4 whole issue of do you have the right conceptual model and
5 then you get into type one and type two type of errors, and
6 that kind of stuff.
7 Do you have a plan for dealing with that?
8 MR. VAN LUIK: That is included in what we are
9 supposed to be looking at. Obviously, the easiest thing to
10 do is to look at parameters. That is another order of
11 magnitude more difficult, but that goes to the
12 interpretation of data, what interpretations does it allow.
13 So it definitely is part of the plan, but whether
14 we get that done in the first phase or the second phase, I
15 would guess it would be the next phase.
16 But we plan to do this to the point that at the
17 time of licensee application, we have our ducks pretty well
18 in a row. But I have to re-emphasize that I think and I
19 think most of the PIs in the program think that these are
20 second order corrections and we have captured the major
21 uncertainties and in several instances we have captured, by
22 analyzing, different conceptual models, for example, and
23 chosen either the more conservative one, which is another
24 source of conservatism, or we have somehow combined them.
25 So there is already conceptual model uncertainty

1 addressed in the TSPA-SR, and the supporting documents,
2 itself.
3 It's not like it's something that we say, oh, gee,
4 we forgot that, but there are the major ones, like in the
5 unsaturated zone, and then there may be some other minor
6 ones, too, that we will want to address further in this
7 exercise.
8 MR. GARRICK: Okay. No further questions, we'll
9 listen to Bob Andrews.
10 MR. ANDREWS: Thank you very much. As Abe said,
11 this is work in progress. The documentation of the analyses
12 and calculations and the model and the report itself are
13 internal to the M&O review and comment resolution as we
14 speak.
15 It's been an incredible team. Most of you are
16 aware of them from the VA. It's been a fairly stable team,
17 I'm very thankful for, and that team is very hard at work
18 still, that team in Albuquerque and here in Las Vegas.
19 I had the joy yesterday of looking at the cover
20 page of the technical report and in the cover page, we're
21 putting all the contributors to the documentation of the
22 TSPA-SR and it was just kind of -- by the time you looked
23 through the 20 or 30 names on there, you were well aware of
24 the hard work and incredible work of pulling this thing
25 together and documented, as Abe said, in as clear and

1 concise and traceable and transparent a fashion.

2 And sometimes, some of those adjectives compete

3 with each other, as though of you who have prepared large

4 documents are aware. You try to make it traceable, but in

5 so doing, you might have lost some transparency, or you've

6 tried to make it transparent, but in so doing, you might

7 have lost some traceabilty.

8 But I think we have a happy medium between those

9 and the issues that were raised by the questioners in Abe's

10 presentation I think have been addressed.

11 My objective today is to kind of walk through the

12 TSPA-SR as it stands right now. The various attributes,

13 look through the system, how the system is connected or the

14 components of the system are connected, and then go to the

15 results.

16 The objective in the hour or hour and a half that

17 we have here is not to go through each individual component

18 part, starting with climate and going through to biosphere

19 and to disruptive events, but to talk about it as an

20 integrated system.

21 If you have questions about an individual part,

22 I'll do my best about how that part was implemented in the

23 TSPA model. As Abe and Russ and Tim and Carol told you, the

24 whole building blocks of this TSPA are those 121 AMRs that

25 provide the technical foundation and the data, in fact, that

1 support those AMRs. Those AMRs, those analyses, model
2 reports have used site-specific data, analog data, as
3 appropriate, in situ data, laboratory data, literature data
4 to develop their technical bases and the technical bases
5 reside in those AMRs.
6 So with that, let me go on, John, to the next
7 slide and talk about process.
8 The next two slides kind of go hand in hand. I
9 think this is a fairly well defined process. This is a
10 pictorial representation essentially of the requirements of
11 TSPA as they are defined in Part 63, where the first step is
12 to identify those features, events and processes that may
13 significantly affect the performance of the repository
14 system, both the engineered features, events and processes
15 and the natural system features, events and processes.
16 We've looked through, starting with an NEA
17 database, which the department and NRC were both a part to
18 in the development of that NEA database, as well as the
19 international community at large.
20 WE added Yucca Mountain specific features, events
21 and processes to that, to the point where it became
22 something like 1,600 features, events and processes that
23 then had to be either evaluated and screened into a model
24 or, with a basis, screened out of the model.
25 Once we've done that and I think the NRC is

1 reviewing the analysis and model reports that relate to the
2 FEPS screening process, we developed two basic scenario
3 classes using the definition in the TSPA-I IRSR of scenario
4 class.
5 Those scenario classes are what we call a nominal
6 scenario class and, in this particular case, of a panic or
7 disruptive events scenario class.
8 IN the disruptive event or volcanic scenario
9 class, there are actually two. I think the parlance in the
10 TSPA-I IRSR is an event class; two event classes, one an
11 intrusive event class and one an extrusive event class.
12 Given that I have those scenario classes, now I
13 have to have the individual component models and the
14 integration of those individual component models and the
15 scientific technical underpinning for those individual
16 component models.
17 In the TSPA, if you come around the wheel of the
18 figure, there are essentially nine of those component parts.
19 There's subcomponents, that I'll get to in a second, that
20 are in a series of backup slides to this presentation, but
21 we start first with the unsaturated zone flow, the things
22 above the repository, climates, air infiltration, et cetera.
23 We then get to the engineered barrier system
24 environments. The environments in the drift, around the
25 drift, in the rock, that can affect the degradation

1 characteristics of the engineered materials that are placed
2 inside the drift, with the proposed design that Abe talked
3 to you and Russ talked to you about.
4 We then get to the degradation of package and drip
5 shield, their performance over time. Next, the waste form.
6 Once the packages are degraded, the waste form starts
7 degrading, the cladding can start degrading, the internals
8 of the package affected by the environments inside the
9 package once they start degrading.
10 We then have transport through the package,
11 through the invert materials, into the rock, and then
12 transported in the unsaturated zone to the water table,
13 transport through the saturated zone, and, finally, we have
14 a biosphere, where the nuclides that are released to the
15 community of individuals -- let's not get involved whether
16 it's a group or maximally exposed, but we'll talk about that
17 a little later -- that group of individuals is exposed to
18 those nuclides.
19 So we end up with a volcanic dose, dose induced by
20 the low probability volcanic scenario classes, and the
21 nominal dose, those that are not impacted by these low
22 probability volcanic scenario classes.
23 As Abe pointed out, there's two other principal
24 performance measures, regulated performance measures, the
25 ground water protection, concentration, however that's

1 finally implemented in Part 63, assuming that it still
2 exists in 197. It does exist in the proposed 197. And the
3 human intrusion dose, assuming, again, that it's implemented
4 in the way Part 63 has it currently in the draft.
5 As you're well aware, Part 197, in its proposed
6 regulation, allows the applicant to potentially exclude that
7 scenario from consideration if the applicant so decides.
8 We have, for the purposes of the TSPA-SR, included
9 that particular scenario class into the assessment. It's
10 not weighted. It's a stylized calculation to evaluate the
11 robustness of the system.
12 The one that's not shown on there is the peak
13 dose, the requirement for the final environmental impact
14 statement.
15 So that is the process of developing the TSPA-SR.
16 If I skip over the word slide, because that's in there more
17 for completeness, and walk now through the various component
18 parts that feed into the TSPA-SR.
19 This set of attributes is very familiar to this
20 board, I know, from the repository safety strategy Rev. 3
21 and also the viability assessment. The viability assessment
22 volumes three and four talk about the major attributes that
23 affect the long-term performance of a repository at Yucca
24 Mountain.
25 All we're trying to do here is trying to put it

1 into a little more general construct and use some icons to
2 point the reader through where they are in the system,
3 starting with the natural system, with the water above the
4 repository, as it gets into the drifts, then the package
5 itself, then the mobilization and release; finally,
6 transport and whatever the consequences and risks associated
7 with disruptive events might be.
8 As a general view, the next slide takes the TSPA
9 wheel for the nominal scenario, a similar one for disruptive
10 scenarios, but this is for the nominal, and shows you the
11 individual component parts and the individual process model
12 factors or subcomponent parts or process models, whatever
13 you want to call it, that feed into that TSPA-SR.
14 This is kind of shorthand notation. In the last,
15 I think, nine slides of your handouts, they're in the
16 backup, I didn't feel it was necessary to go through it in
17 the presentation, but I think it's to provide you a road
18 map, if you will, from the feeds into TSPA, which are shown
19 here and the individual component parts that are shown
20 there, to show you what analysis model report is the final
21 analysis model report providing the input parameters, the
22 input parameter distributions, discussion of alternative
23 conceptual models, discuss the technical bases for those
24 parameters, what those ones are.
25 So it's a tabular mapping that takes the

1 individual parts, piece parts shown on this wheel, tells you
2 what parameters those piece parts are generating. There's
3 on the order of several hundred parameters that are being
4 generated for input into the TSPA, and shows you where the
5 supporting documentation is for that.
6 It gives you the analysis model report title, the
7 analysis model report number.
8 So I believe the Commission has, I think, as Russ
9 said, 119 of those. So I believe all the ones that are
10 indicated there, the Commission has.
11 That's more of a traceability completeness kind of
12 backup presentation than for you to necessarily do anything
13 about, unless you want to review those AMRs.
14 So the next set of slides just walk through those
15 process model factors, the individual component parts that
16 feed into the TSPA model, starting, first, with those that
17 affect the attribute. That's the water contacting the waste
18 package. So climate, infiltration, UZ flow, the effects of
19 thermal hydrology on the in-rock processes and, finally,
20 seepage into the drifts.
21 The next slide shows those principal factors that
22 are affecting the environment inside the drift, the
23 environment that the engineered barriers are likely to see
24 as they change with time after the wastes are emplaced. In
25 particular, the chemical environment and the thermal

1 hydrologic environment.

2 Also in that physical environment are the stress
3 environments associated with the degradation of the drifts
4 themselves.

5 The next slide looks further into the drifts and
6 this is essentially looking at those component parts that
7 relate to the degradation characteristics of the drip shield
8 and the degradation characteristics and projected
9 performance of the waste packages themselves.

10 Next slide gets into the internals of the package.
11 We have two basic types of packages, one being the
12 commercial spent nuclear fuel packages and one are what have
13 been termed the co-disposed packages. It's co-disposed
14 glass, logs with DOE spent nuclear fuel rods going down the
15 center.

16 In addition to these, though, there are other
17 kinds of packages, special packages, for example, the Naval
18 wastes have specialized packages because of their size and
19 handling requirements.

20 But these are the two principal ones and any other
21 special type package, we've done a special off-line analysis
22 of the consequences associated with that kind of inventory
23 and that kind of waste, if it's different from these kinds
24 of wastes.

25 The next slide, it should be pointed out that

1 there are on the order, for DOE type wastes, there are on
2 the order of several hundred different specific waste forms.
3 There are not data on every one of those specific waste
4 forms, so the DOE spent nuclear fuel program, for our
5 purposes, has lumped those waste forms into 13 individual
6 types of waste forms, with similar types of characteristics
7 and similar types of inventories and similar expectations
8 about the degradation of the cladding associated with those
9 waste forms.
10 The next slide talks to the transport aspects,
11 away from the engineered barriers. In particular, transport
12 through the unsaturated zone, transport then through the
13 saturated zone, and ultimately the uptake of these
14 contaminants by the biosphere group and whatever dose
15 consequences are associated with the uptake and use of the
16 water that may have been contaminated at some point in time
17 by the other degradation processes and transport
18 mobilization processes.
19 The next slide shows that when we have a volcanic
20 event, with the probabilities that are currently being
21 estimated, and I believe you talked about those yesterday,
22 when you talked about the KTI meeting on igneous activity.
23 Right now, we're sampling that probability from the expert
24 elicitation that was performed on the probability of an
25 igneous event, but we have then two types of consequences.

1 So, therefore, two types of event scenarios that
2 are being assessed. Type one is the event occurs,
3 intersects the repository, degrades the package and the
4 event conduit continues to the surface and you have a cinder
5 cone and an ash associated with that. The ash is
6 redeposited with the wind over the member or members of the
7 critical group and there's a dose associated, potential dose
8 associated with that release pathway.
9 That one we've called an extrusive volcanic event
10 or an eruptive volcanic event scenario event class.
11 The other possibility is that the dike intersects
12 the repository, degrades the packages sufficiently so
13 they've lost their containment possibility, degraded the
14 drip shields, degraded the cladding, and then the normal
15 processes of the nominal scenario take place; i.e., all the
16 slides that I had in there earlier about radionuclide
17 mobilization, alteration of the waste form, release from the
18 waste form, transport through the engineered barrier system,
19 transport through the UZ and transport through the saturated
20 zone, and then uptake in the well and biosphere dose
21 consequences associated with that.
22 So we have two very different pathways, all with
23 the same initiating probability, but very different
24 consequence models from that initiating probability on.
25 They are then, of course, combined at the end for the same

1 event.

2 If I go to the next slide, the regulation

3 currently requires stylized human intrusion scenario. This

4 is that stylized human intrusion scenario. Somebody drills

5 inadvertently, goes through a package, goes through the

6 waste form, goes back through the package, back through the

7 EBS and down, continues down to the saturated zone, and then

8 radionuclides can be mobilized, released from the package

9 through that degraded -- what now is a degraded engineered

10 barrier, through what now is a degraded unsaturated zone

11 barrier, and through into the saturated zone and then the

12 other processes take their normal course.

13 The next slide tries to summarize, I think, what

14 Russ has told you, what Abe has told you, and I'm going to

15 go into a little more detail on some of the following ones

16 on.

17 The technical bases -- turn back to the viability

18 assessment. The viability assessment, volume three of the

19 viability assessment, which I know this panel reviewed, had

20 a large technical basis document that went along with it,

21 essentially nine chapters. That provided the individual

22 bases for the individual component models in the viability

23 assessment.

24 In the SR or the SRCR TSPA that we're talking

25 about here, that nine got expanded to nine process model

1 reports, which are very similar, slight differences between
2 the technical basis document and how they've lumped the
3 process model reports.
4 But the fundamental science is embodied in those
5 121 AMRs, analysis model reports, developed by the labs and
6 the GS and M&O participants to support the TSPA-SR.
7 Of those 121, 40 of them are direct feeds into the
8 TSPA. So those 40 provide a direct data set or model or
9 conceptual model or equation or something, are a direct feed
10 into the TSPA.
11 You say, well, what about the other 80. Well, the
12 other 80, probably 15 of them relate solely to screening
13 arguments, features, events and processes screening
14 arguments. The other 65 are process models. They are
15 alternative models. They are supporting models that feed
16 into those 40 that ultimately support the TSPA model itself.
17 So all 120, we have several family trees of these
18 120 and how the information flows in all 120 AMRs takes
19 about 15 figures to show all of that, and we've put that in
20 the appendix of the TSPA document, to show where did all the
21 information come from to support the final feed into the
22 TSPA.
23 So one can very, very quickly and very easily pull
24 the chain, pull the string, and go back to the AMR that gave
25 the technical basis for its inclusion in the TSPA.

1 And I might add, based on the discussion that was
2 going on before, the technical bases for the assumptions
3 involved in those analyses and models and if there were
4 assumptions on degree of conservatism or degree of
5 complexity or something that's going to be treated as a PDF
6 or something that's not going to be treated as a PDF or
7 something that's not going to be treated as a PDF and the
8 reasons for that, it's in those supporting analysis model
9 reports.
10 The 40 that feed directly into the TSPA-SR model
11 are shown on this slide. This is the one you need in
12 addition to Russ' pyramid, the one you need the magnifying
13 glass for. Actually, the next one, too, you'll need a
14 magnifying glass for. In the actual document, they appear a
15 little bit bigger.
16 But the color coding is color coding the AMRs to
17 the corresponding process model report in which that
18 analysis model report is summarized and the arrows are
19 showing where in the TSPA model are the individual component
20 analysis model reports input and then where in the middle is
21 the process of doing the TSPA, starting with the package
22 degradation, going to waste form degradation, going to EBS
23 transport, UZ transport, SZ transport, and, finally, the
24 biosphere.
25 That middle part is the guts of the TSPA model, if

1 you will. All of those inputs are what's being integrated
2 within the context of the TSPA model.
3 If you don't like boxes, then the next two slides
4 try to walk it through from an information flow point of
5 view; what information, what kind of, if you will,
6 intermediate result is passing from component to component
7 within the TSPA model.
8 One of the objectives of the TSPA model itself and how it's
9 been constructed and how it's been documented is to show, in
10 as transparent a fashion as possible, given that I have 40
11 AMRs that are feeding it, as transparent a fashion as
12 possible, how the information flows from component to
13 component; how does climate information flow to unsaturated
14 zone flow; how does unsaturated zone flow information flow
15 to seepage; how does thermal hydrology information flow to
16 the degradation of the package, degradation of the cladding,
17 degradation of the drip shield; how does thermal hydrology
18 information flow to the characteristics of the invert, the
19 thermal and hydrologic characteristics of the invert.
20 So there are placeholders within the TSPA model
21 where we go in and we've done this in the technical report
22 and in the model document, where we go in and stop the
23 results, if you will, and look at what information is
24 passing from component to component; what flux, it's general
25 energy kinds of things.

1 It's heat that's passing from component to
2 component, it's mass that's passing, it's volume of fluid
3 that's passing from component to component, and ultimately
4 it's -- and it's chemistry passing from component to
5 component, and, ultimately, it's radionuclide activity
6 that's passing from component to component.
7 You can say that from barrier to barrier, you can
8 say it from feature to feature, but it's traceably and
9 transparently showing how that system evolves based on the
10 models available through time.
11 Some of that information, as a backup, I've
12 included, in the first part of your backup slides, I was not
13 going to go over it here unless it gets into that level of
14 detail. But as we go from flow to seepage to package to
15 water mass movement, mass release, activity release, and
16 ultimately activity release at the 20 kilometer point of
17 compliance, that ultimately leads to a dose. That's all in
18 the backup and it's in greater detail in the technical
19 report.
20 So these two slides show that how information
21 flows from part to part. Same thing on slide 17. It shows
22 once I get internal to the engineered barriers, that is
23 internal to the drift, how the environments are propagated
24 through time and what downstream processes impact, and then
25 how the degradation characteristics of the engineered

1 barriers are propagated through time, and then ultimately
2 the release, mobilization and release of nuclides from those
3 engineered barriers and back into the natural barriers.
4 The next slide, Abe alluded to this. Uncertainty
5 and variability, both primarily quantified, has been
6 directly incorporated in the TSPA-SR model. The third
7 bullet there is a bullet that Abe had on his slide and that
8 is where the individual analysis model report originator,
9 the reviewers, the checkers, felt there was either a large
10 degree of complexity, large degree of uncertainty.
11 The goal was to be defensible and in being
12 defensible, they were probably, in some cases, a little
13 conservative. They documented that in their analysis model
14 report. Are there alternatives they could have chosen?
15 Yes. Did they document what those alternatives were? Yes.
16 Did they give a rationale why they didn't choose that
17 alternative? Yes.
18 Could we propagate those alternatives back through
19 the rest of the system in sufficient time? Maybe, because
20 some of those alternatives require alternative
21 representations. They require alternative data. They
22 require alternative analyses and they require alternative
23 abstractions into the performance assessment.
24 It's not a simple flick the switch. It is in some
25 cases. If it's down at a parameter level, I think Andy's

1 question is very well taken. If it's down to the parameter
2 level, it is a very simple aspect. If you don't have the
3 process model for how you think -- take the example that was
4 alluded to earlier, the stainless steel degrades and that
5 degradation characteristics are sufficient complex and the
6 amount of information available in the environments that we
7 have is sufficiently uncertain, it would have taken a big
8 effort to incorporate stainless steel into the TSPA model.
9 First, the process model, then the abstraction,
10 and finally into the TSPA model. So a conscious decision
11 was made by all concerned, including the Department of
12 Energy, in that particular case and others, of which things
13 to include and which things to exclude and carry those
14 excludes.
15 MR. GARRICK: Bob, just to pick up on that a
16 minute. Obviously, you have to have some evidence in order
17 to assign a number or a parameter that you think represents
18 an upper bound or a conservative estimate.
19 It just seems that it would be easier to hedge
20 your bets with a discreet probability distribution, for
21 example, than it would be a single number. In other words,
22 you talk about an unquantifiable event or number or
23 parameter, on the one hand. On the other hand, you say you
24 assume conservative values.
25 So you've got to have some basis for justifying it

1 as a conservative value.

2 MR. ANDREWS: I think they do. I think --

3 MR. GARRICK: And my point is this. It's easier,

4 as a matter of fact, to justify some sort of a distribution

5 than it is a single value.

6 MR. ANDREWS: You're right. To justify the

7 distribution, in some cases, say I think I'm pretty sure

8 it's within this range. I have evidence to say it could be

9 at low values, pick the parameter, pick the model, it's the

10 case all across the board.

11 There's evidence to support it down here. There's

12 evidence to support it up here. There's evidence to support

13 it in the middle. It might be analog evidence. It might be

14 direct field observations, whatever the evidence is.

15 However, when faced with the requirement of being

16 as defensible as possible and to not be optimistic with how

17 performance may evolve in this system over time, the

18 analysts, I believe, personally, correctly, went with the

19 conservative approximation.

20 There have been words in Part 63 or in the

21 statement of considerations, perhaps, I'm not sure where

22 they were for Part 63, that if the applicant -- it might

23 have been 60, in fact, I forget where they were -- if the

24 applicant has uncertainty in a particular aspect or

25 alternative representations or alternative models, it is

1 okay to include those alternative models and alternative
2 representations in your performance assessment, but we still
3 want to see the effects of that more deterministic, more
4 conservative representation.
5 MR. GARRICK: That's not a particularly
6 unreasonable approach. My only point is you don't want to
7 get yourself trapped into saying, on the one hand, that you
8 have no information, and, on the other hand, you're using a
9 number that's characteristic of information.
10 MR. ANDREWS: That's well taken. That's a point
11 well taken.
12 The next three viewgraphs summarize some of these
13 aspects in a kind of Consumer Reports sort of fashion of
14 what uncertainty was directly incorporated in the TSPA-SR
15 model, what variability, and this is generally spatial
16 variability, was included in the TSPA-SR model, and a brief
17 set of comments.
18 The comment, if I didn't check uncertainty or
19 variability, those are generally the ones where a more
20 conservative representation was taken within the analysis
21 model reports in order to avoid some of the complexity
22 associated with that particular process or coupled process.
23 The very first one on there, on page 19, is the
24 coupled effects on seepage. This was one that also was
25 noted in our review of the viability assessment, it's been

1 noted several times by the Nuclear Waste Technical Review
2 Board, noted by NRC staffers and center staffers on their
3 review of the viability assessment, as well.
4 And that is that the actual seepage into a drift
5 following emplacement and the perturbations that are caused
6 by emplacement, the mobilization of water, the changes in
7 the chemistry, the changes in the mechanical stress around
8 the drift, the degradation of the drift support system
9 itself, all of the thermal mechanical hydro chemical coupled
10 processes are -- I think everybody would acknowledge are
11 very difficult to quantify with a high degree of
12 defensibility.
13 There are data, yes. There are data from the --
14 specific data, even, associated with seepage tests that have
15 been conducted by Berkeley in various niches at the site,
16 the actual thermal hydrologic drift scale test at the site,
17 smaller scale thermal hydrologic tests at the site to
18 support and plus modeling and analyses of coupled thermal
19 chemical processes.
20 There are data to support a range of possible
21 effects associated with thermal hydro chemical mechanical
22 stress evolution at the site.
23 But it's fairly broad what the possible outcomes
24 are in terms of their effects on the rock properties, the
25 permeability, the fracture aperture, the capillary suction

1 in and around the drift.

2 Therefore, because of that complexity and because

3 of that uncertainty in what is the most reasonable, the most

4 defensible model for seepage in the effects of all these

5 coupled processes, a conservative assumption was taken that

6 take the flux five meters above the drift, I think the

7 bullet says there, and put that flux into the seepage model.

8 Don't try to capture all the nuances of what

9 happens in the first ten centimeters or the first millimeter

10 of the drift wall as the drifts are degrading with time.

11 So that's not uncertainty, it's not variable in

12 the model.

13 Is the actual seepage into a drift uncertain?

14 Yes, because the seepage model itself is uncertain and the

15 flux itself is very uncertain and highly variable.

16 But the coupled processes and the complexity

17 associated with those was, in this particular case,

18 eliminated by making this conservative assumption. I should

19 point out that that was, going back to the TSPA-VA, that

20 was, in fact, a recommendation of the peer review panel to

21 say in order -- the complexities associated with this one

22 are so large, you, department, may be better off simplifying

23 it and that's what we've done.

24 George is biting at the bit here.

25 MR. HORNBERGER: Just a quick question on that.

1 The TRB has been critical of this particular aspect and one
2 of the contentions is that some of this uncertainty may, in
3 fact, be diminished or go away if the temperature of the
4 repository were lower.
5 Can you give me the basis of that? Do you agree
6 with that contention and if so, what's the basis of reducing
7 the uncertainty? The coupled processes are still there, is
8 that right?
9 MR. ANDREWS: Yes. Even at 70-80 degrees C, you
10 still have coupled processes. You still have mechanical
11 processes at zero degrees C. As soon as you open that
12 drift, you have mechanical degradation processes that will
13 kick into gear and then you have the thermal hydrologic
14 coupled processes and the thermal chemical coupled
15 processes.
16 I can't speak for the board and their beliefs
17 about reducing uncertainty with cooler repositories. I
18 believe it's not totally tied to this particular one. I
19 mean, this is what gets the focus, but it's also on the
20 degradation characteristics of the engineered barriers in a
21 cooler -- where cooler now is 70, 80, 90 degrees C,
22 environment rather than 120, 130 degrees C.
23 So it's not solely in the rock that they're after.
24 MR. HORNBERGER: I'm not asking you to speak for
25 the board. I was just asking, in your experience in doing

1 TSPA, would the uncertainties be significantly reduced at
2 these lower temperatures?
3 MR. ANDREWS: No. We got enough uncertainty.
4 MR. GARRICK: It just may be displaced.
5 MR. ANDREWS: It might be displaced in time.
6 MR. GARRICK: Right.
7 MR. ANDREWS: I don't know if you want to pick up
8 any other of those that don't have checkmarks, but if I go
9 to the second page, for example, I think it's a useful one
10 on the waste form characteristics and the waste form
11 degradation.
12 There are a number of fairly complex processes
13 that occur once water, in whatever form it exists, whether
14 it's humid air or actual liquid water, when it comes into
15 contact with the waste form, there are very good data
16 collected at PNL, at Argonne, at Lawrence Livermore Labs,
17 and internationally about the degradation characteristics of
18 the waste forms.
19 Those data have been used, but they have a fairly
20 broad range and the applicability of that range under the
21 exact environments that we're expecting is uncertain. We
22 could have used that range or we could have used a more
23 bounding value.
24 What's there right now in Rev. 00 that we're
25 talking about is that more bounding value for the waste form

1 characteristic degradation.

2 I don't know if there's any -- in package

3 transport, that's another nice one. What the internals of

4 the package look like after the package has degraded, as a

5 function of time. The characteristics of the basket

6 material, the degradation of the basket material, the

7 stresses involved inside the package, the hydrology in the

8 package, the chemistry inside the package are very

9 uncertain, very uncertain.

10 And for anybody to confidently predict the

11 internals, with the exception of some basic fundamentals

12 like temperature, would be -- well, it would be difficult.

13 So a more bounded type approach was taken of bring

14 that mass, bring that activity, once the waste form is

15 altered, to the edge of the package, the inner edge of the

16 package.

17 So transport inside the package, transport along

18 fuel rods, transport through a degraded fuel rod assembly

19 was not taken credit for in the Rev. 0 TSPA-SR. And that

20 would require, obviously, a different model, different

21 representation, alternative conceptual model of how you

22 think the internals of the package perform over time.

23 It is much simpler, much more defensible to take

24 the more conservative approximation in this case.

25 By the way, most of these have limited effect,

1 where limited is small, effect on the post-closure
2 performance. WE did not make the collective decision of
3 where to add conservatism based on things that were highly
4 important to performance.
5 So it was generally focusing on those that were
6 less significant to performance. One exception to that is
7 this secondary phase issue that's a bullet on the waste form
8 degradation and solubility limits.
9 There's no other -- well, there's other
10 interesting ones in here, but maybe that -- I think those
11 examples, I think, are probably sufficient to walk through
12 the process, the collective decision-making that was done.
13 As Abe told you, each one of these are being
14 examined with this small group, evaluating is there --
15 should we look at quantifying this uncertainty and if we do,
16 should we then run a calculation to see what the impact of
17 that particular aspect on the system performance was.
18 I think taking Dr. Garrick's point to heart of now
19 that we have the tool, it's running, it works, we believe
20 giving reasonable results, now it's kind of time to exercise
21 the tool with alternative representations, gain additional
22 understanding.
23 MR. WYMER: It's a little disturbing to me that
24 most of the areas that are unchecked, or many of them, are
25 chemistry related areas and to a chemist, those don't look

1 any more difficult than some of the other complexities which
2 have been taken into account.
3 And in some of them, like second phase formation,
4 you may have quite a profound effect on the release of
5 radionuclides, where it would be significant in the dose to
6 the person at 20 kilometers.
7 So it seems to me that, from a prejudice point of
8 view, what I see is that reflection of the knowledge and
9 backgrounds of the people doing the study rather than
10 reflection of the difficulty of doing the analysis.
11 MR. ANDREWS: Well, there are a lot of good
12 geochemists working on this project and who have supported,
13 through their analysis and model reports, supported the
14 development of these inputs.
15 The one example you pointed to is a very near and
16 dear example to many of our hearts. It was an example that
17 we used in the VA, in the viability assessment. It's an
18 example we've had extended discussions on with the folks at
19 Argonne who are doing the detailed fuel testing and
20 characterization of the alteration phases of the fuel.
21 It's a point that I think has been made by NRC and
22 center staff with respect to review of Pena Blanca and
23 utility of Pena Blanca as a very valuable analog for waste
24 form degradation and mobilization and transport of some of
25 the actinides that we're talking about here.

1 MR. WYMER: There are other kinds of chemists than
2 geochemists, you know. There are inorganic chemists and
3 physiochemists who could give a good deal of insight here.
4 Geochemists have their own point of view.
5 MR. ANDREWS: Well, I'm not going to get into that
6 debate.
7 MR. WYMER: Unfortunately, I have one sitting next
8 to me.
9 MR. ANDREWS: But the point is well taken and I
10 think there are complexities associated with the controlling
11 phases as these materials degrade. There is complexity
12 associated with some fundamental thermodynamic information
13 on these controlling phases. Not so much on the uranium
14 side, but for -- when I put neptunium in them or plutonium
15 in them, those fundamental thermodynamic information, I
16 think, is -- I'm not a geochemist, so excuse my bias, but I
17 don't think some of that fundamental thermodynamic
18 information is available.
19 I think there was a presentation to the technical
20 review board in Reno by Dr. Glassly from Livermore and he
21 pointed that uncertainty out as well, that some of the basic
22 thermodynamic data is just not there, and I think the board
23 -- I forget -- one of the board members asked him, well, are
24 we pushing to get that kind of information, and his response
25 was, well, I hope so, but it sounds like fundamental

1 university type laboratory research to come up with those
2 data.
3 And in the absence of some of those thermodynamic
4 constants and time stability constants, it was difficult for
5 -- in the high defensibility role that we wanted to be in,
6 to take credit for some of those aspects.
7 Is there more that we could gain there? Sure as
8 heck is. And I think Dr. Ewing was a member of our peer
9 review panel or DOE's peer review panel, I should say, and
10 he, I think, shared your kind of comments on the VA. I
11 think they are throughout the VA comments.
12 It's pretty complex.
13 MR. WYMER: Yes. No more complex than some other
14 aspects, though, that are dealt with, in my judgment. But,
15 okay. I'm not going to beat a live horse.
16 MR. ANDREWS: Okay.
17 MR. GARRICK: By the way, Bob, these are excellent
18 exhibits. I must like matrices, because these are very
19 helpful.
20 MR. ANDREWS: Good. Okay. Now, we've set up the
21 stage. It's time to get to some results, preliminary
22 results.
23 The first result slide, John, why don't you go
24 ahead with the VA, puts it into context of what the TSPA-VA
25 result that's most comparable to the results that I'm going

1 to be showing to you.

2 In the VA, of course, we did not have Part 63 or

3 197 on the street as proposed regulations. I think they

4 came very shortly after the summer of '98.

5 However, there was enough discussion, I think,

6 with ACNW, with NRC staff, that we had fairly good knowledge

7 of what was going to be in the draft regulation when it came

8 out, which was a slightly different way than we were doing

9 most of our plots in the VA, quite frankly.

10 The how one does the expected, quote-unquote, the

11 dose -- just the mathematics of doing that calculation was

12 slightly different than the way we were proceeding in 95

13 percent of our plots that we presented in the VA.

14 But we had one set of plots, shown here, figure

15 4-28, that most closely represents for the nominal -- this

16 is nominal scenario class in the VA -- most closely

17 represents the way NRC ended up writing the proposed Part

18 63.

19 What I've shown here is the 95th percentile mean,

20 i.e., expected median and the 5th percentile is actually off

21 the curve. The 5th percentile was zero out to 100,000

22 years.

23 So it gives you an idea, backed with VA models, VA

24 assumptions, whether they were good, bad or indifferent, VA

25 design, this is the comparable VA, TSPA-VA result for the

1 slides that are going to be following. I did not change the
2 time access to be logged like the subsequent ones are.
3 There have been a lot of changes. As Abe pointed
4 out, there was a number of changes. There was hardly a
5 model that didn't change between the VA and the SR. The
6 design changed from the VA to the SR and in some cases, the
7 approach changed between the VA and SR.
8 So the following slides all relate to those 121
9 AMRs and their incorporation in the TSPA.
10 So let's skip to slide 24. What I've shown you
11 here or have up here are 300, the skinny little lines are
12 300 individual realizations of the total system performance
13 based on those 40 AMRs, cranking them through with their
14 uncertainty and their individual parameters and models, et
15 cetera.
16 So each one, each one of 300 has an equal
17 likelihood of occurring. We then superimposed on top of
18 those 300 four basic statistical measures of each one of
19 those, essentially done in a per year basis, where per year
20 really means, in this case, per time step and time step is
21 about 25 years.
22 So it's per time step slice and I've shown the
23 95th percentile, the mean or the expected value, the median
24 or the 50th percentile value, and the 5th percentile value.
25 Several things to note on this slide. One is

1 there is quite a wide spread, variance, if you will, of the
2 dose as a function of time. If I'd look at it at any
3 particular time, there is a wide variation of dose. If I
4 look at any particular dose, it's a wide variation of time.
5 So it's quite a wide spread. Understanding that
6 spread, that distribution of the results is an important
7 component of performance assessment, and we're going to
8 spend a little more time talking about that, why the broad
9 spread.
10 If you look at 100,000 years, that spread is going
11 over seven or eight orders of magnitude. It's very broad.
12 Another point of observation is in those 300
13 realizations, for the data that are contained within the
14 analysis model reports, for the models that are supported in
15 those analysis model reports, none of them had a failure of
16 the engineered barriers prior to 10,000 years in this
17 nominal scenario class.
18 We'll look at some examples in just a second where
19 that's not the case. It's not the case in the volcanic
20 event and it's not the case in human intrusion, but for the
21 nominal performance, the expected performance, with its
22 uncertainty embedded in there, none of them failed before
23 10,000 years.
24 Your logical question is, is it impossible to have
25 failures before 10,000 years, and the answer is clearly no.

1 There is a probability of having a degradation prior to
2 10,000 years, that we'll get to here in a second. But for
3 the nominal performance over that many realizations, there
4 were none.
5 You might ask how did you pick 300, why didn't you
6 use some other number. Well, our goal was to get a stable
7 mean, not a stable 5th percentile or a stable 95th
8 percentile, but a stable mean and we ran 100, 300 and 500
9 and 300 was stable enough, 500 was sitting right on top of
10 300. So we stopped at 300. Just totally economics related
11 to why 300 and not 500. They're one on top of each other.
12 The difference between 100 and 300 is not that
13 much, it's probably 20 or 30 percent, and we have those
14 plots in the technical report as backup.
15 Other points of information are probably best
16 explained by looking at the next slide.
17 MR. LEVENSON: Bob, before you leave that one. Is
18 that correct that the 95th percentile line crosses the mean?
19 MR. ANDREWS: Yes. And you'll see it also when we
20 get to volcanic, in a way, that the 95th percentile can
21 exceed the mean; i.e., the mean is driven by the top two or
22 three percentile of the distribution, which is what you're
23 seeing right there.
24 The next slide talks to the principal nuclides
25 that are controlling this dose rate and all I've done is

1 taken, for the expected value case, this is now expected, I
2 have to be careful here, this is expected value of the
3 output.
4 So this is based on -- still based on 300
5 realizations of the probable performance of the repository
6 system and I'm just looking at one expected value from that,
7 and then what are the nuclides that are controlling that
8 expected value.
9 And what you see here, quickly, is that up till 40
10 or 50,000 years, we are dominated by the very high
11 solubility, unretarded, diffusing radionuclides, like iodine
12 and technetium, same thing we had in the VA.
13 That at early times, those things that are
14 unretarded, those things with very high solubility which can
15 diffuse through thin films or long thin film boundaries,
16 they are released first.
17 After a while -- in this case, it ends up being
18 about 50,000 years -- it's the lower solubility, retarded,
19 but not completely retarded nuclides. They diffuse a little
20 bit, but they're more controlled by how much water advects
21 through the system, how much water advects through the
22 package and through the invert, neptunium and the colloidal
23 plutonium.
24 This is -- we have two colloidal plutonium species
25 that are being tracked in the TSPA-SR and those are the ones

1 that are coming out at longer times.

2 I should point out that a large fraction of the

3 inventory, of the total inventory is still retained either

4 in the waste form or in the waste package or in the EBS,

5 simply because of the very low solubility or very high

6 retardation characteristics of those other nuclides.

7 So what we see here is things coming out and

8 trying to understand why they come out and what is the order

9 in which they come out, but there's a lot of other things,

10 and I did not bring that plot, but we show the plot in the

11 technical report, that are retained and that are essentially

12 delayed significantly before they come out and provide any

13 kind of dose consequence.

14 There's a little bit of understanding that can go

15 into these plots, but that understanding really resides in

16 the backup slides. Part of it's clear that until you have

17 the primary containment barrier, i.e., the package, degraded

18 and you get water into the package, you have no release.

19 Even when you have the package degraded, and, generally, and

20 there's backup slides to point this out, for your benefit,

21 once the package degrades, it's generally degrading at the

22 closure welds.

23 It's generally degraded by stress corrosion

24 cracking at those closure welds. Those cracks are micron

25 size. So liquid water is not getting into those cracks.

1 There's an analysis model report to support that. But humid
2 air can get into those cracks and nuclides through humid air
3 condensing on the waste form itself and that other
4 conservative assumption that we talked about earlier, about
5 the innards of the package and how they're being treated,
6 nuclides can diffuse through those cracks in the stress
7 corrosion cracked welds of the earlier package failures.
8 So what you see here for iodine and technetium is
9 diffusion through very thin cracks, while the drip shield is
10 intact, but the packages have degraded at the closure welds.
11 At later times, the drip shields are degraded.
12 Liquid water for that fraction of the repository that has
13 seepage, which is depending on the timeframe and the climate
14 state and the percolation flux, et cetera, the fraction of
15 packages that see seepage changes with time.
16 But for that fraction that sees seep and for that
17 fraction where the drip shields have degraded and the
18 packages have degraded, liquid water can get into the
19 package and liquid water can take away nuclides from the
20 package, through the package, through the invert, and back
21 into the rock, and that's when you see neptunium and
22 plutonium taking over.
23 MR. GARRICK: Have you somewhere cast these into a
24 dose exceedence CCDF form?
25 MR. ANDREWS: No.

1 MR. GARRICK: That would be very -- that
2 communicates very well. I just wondered if you had
3 considered that, especially for the disruptive events which
4 have a recurrent cycle to them.
5 MR. ANDREWS: I appreciate that, John. We
6 struggled internally on communication of this and, quite
7 frankly, in polling people, obviously, we didn't poll you,
8 we concluded that CCDFs, although explanatory for some
9 fraction of the audience, were obfuscating for a large
10 fraction of the audience and, therefore, we -- including
11 people who were on our peer review panel before.
12 So reasonable people. So there was a transparent
13 --
14 MR. GARRICK: These are important curves, but from
15 a risk perspective, the CCDF is the risk curve, whereas
16 these are not.
17 MR. ANDREWS: Right.
18 MR. GARRICK: These are just probabilistic dose
19 curves.
20 MR. ANDREWS: These are risk when you multiply
21 them by .999, which is what these are.
22 MR. GARRICK: Yes. But I would think that
23 especially for the disruptive events, it would be a useful,
24 a very useful presentation to be able to --
25 MR. ANDREWS: That's a good suggestion.

1 MR. GARRICK: -- answer the question in one
2 diagram what the risk is.
3 MR. ANDREWS: That's a good suggestion. We had a
4 little dialogue with some other review groups on how to
5 prevent the disruptive event work, and that would be, I
6 think, a good suggestion. We have not implemented that yet.
7 MR. GARRICK: Okay.
8 MR. ANDREWS: Let me go on to slide 26, the one
9 looking at longer-term performance. This particular slide
10 and the one that follows, which talks about the key nuclides
11 associated with this slide, is the case of extrapolating
12 those models used in the 10,000, 100,000 year performance
13 results, extrapolating those models on out to a million
14 years.
15 We understand, as we read proposed 197, that that
16 maybe isn't exactly what they intended, but this shows what
17 the impacts of doing that would be.
18 We stopped at a million because of 197 saying that
19 was the time period of geologic stability, which is also the
20 time period the NAS thought was of geologic stability. I
21 think it reasonably captures the peak. You can see the
22 peaks are coming down as you go out past two or 300,000
23 years, coming down primarily because either things are
24 slowly but surely decaying.
25 Some of these nuclides have very long half-lives,

1 so they're still in the system or they're being absorbed or
2 they've come out of the system.
3 One thing -- I think that's probably enough to say
4 on that particular curve and the following curve.
5 Let's go to the disruptive events, the igneous
6 activity scenario class. This one. This is the one that I
7 think Abe said things were in checking or in review. This
8 is the curve that's different a little bit from the curve
9 that we presented in the beginning of August to the Nuclear
10 Waste Technical Review Board, and I'll walk through that
11 difference here in a second.
12 But before I do that, let me talk to the form and
13 structure of this particular set of curves. At the
14 left-hand side, you see some nice smooth responses. The
15 curves all more or less look the same. You just have a
16 distribution around a mean or around the median for those
17 curves.
18 Those curves are all the extrusive igneous event,
19 whereby the pathway is -- the event goes through the
20 repository, intersects the package, takes a fraction of the
21 waste up, entrains it, and then the wind blows south and the
22 waste is deposited over the landscape along with the ash and
23 the primary pathway is an inhalation type pathway associated
24 with that release.
25 So there is a wide uncertainty on those, being

1 driven by the number of packages that are hit, by the
2 probability of occurrence. These particular curves are
3 still sampling the probability of occurrence over that
4 distribution from the expert elicitation, uncertainty in the
5 wind speed, et cetera. So there is a distribution around
6 that.
7 Another thing I should point out on this is these
8 are probability weighted dose rates. These are not
9 deterministic doses, given the event occurs, what's the
10 dose. These are already factored into the analyses for
11 comparing apples and apples to make them comparable to the
12 other slides, have already factored that probability into
13 the dose rate.
14 So this really is a risk. So that 95th percentile
15 is 95th percentile not of the total distribution, I think
16 this is getting to your point where I think, John, it's a
17 really good suggestion, this is 95th percentile given the
18 event. So it's conditional.
19 And I think if you showed the complete, either as
20 a PDF or probably better, as you point out, as a CCDF, the
21 full distribution from probability one to probability
22 ten-to-the-minus-eight of dose consequences, you probably
23 would have a clear picture of the overall system, whereas by
24 probability weighting it, which is the way Part 63 asked us
25 to do it, but by probability weighting it, you've lost that

1 consequence time probability factor, because it's already in
2 there.
3 The third thing to point out, which is the reason
4 the slide changed from what we did before, is the right-hand
5 portion of the slide.
6 What I have shown here is actually 500
7 realizations, individual realizations, but there's actually
8 5,000 realizations that are behind this particular plot.
9 You say, well, my gosh, why did you go to 5,000 in this
10 case.
11 Well, the reason is in order to get a stable mean
12 on the dose consequences associated with the indirect
13 intrusive event, so the volcano goes -- well, it's not a
14 volcano, now it's a dike, the dike goes, intrudes the
15 repository, degrades the engineered barriers, and then the
16 natural system takes over.
17 The timing of when that event occurs, of course,
18 is very uncertain. So it's being stochastically sampled in
19 here. But the consequences are a function of the
20 uncertainty and all the other aspects of the system,
21 uncertainty in the unsaturated zone, uncertainty in the
22 saturated zone, uncertainty in colloids, uncertainty in
23 seepage, all the other uncertainties take over or get a
24 distribution of dose responses for the indirect intrusive
25 volcanic event.

1 And simply put, in order to get a stable mean, we
2 had to go to 5,000 realizations over a 50,000 year time
3 period. That's why the plot stops at 50,000 years. In
4 order to get a more reasonable stable mean, that's the red
5 line there, for the risks associated with the indirect
6 intrusive volcanic event.
7 So this curve is slightly different in the
8 presentation that we gave to the TRB back in the beginning
9 of August. We had, I don't know, 500 realizations, not
10 5,000 realizations, for this particular plot. So the plot
11 is a little different.
12 Let's see. The next plot essentially just
13 combines the two expected cases. So looking at the means of
14 the distribution of the nominal performance and the means of
15 the distribution of the igneous scenario classes, we
16 essentially just add them.
17 And these are now correctly weighted by the
18 probability. The probability, when I combined them, is one.
19 The probability of one is .999.
20 And you see for this case the predominance in the
21 first 10,000 years is driven by the low probability, but
22 high consequence igneous event scenario classes, something I
23 think the NRC has pointed out or alluded to in their review
24 of the VA and I think in earlier documentation that they
25 have produced.

1 MR. WYMER: Before you leave these curves, which
2 are very interesting, it occurs to me that with the
3 exception of the igneous activity curves, the other curves
4 all start at post-10,000 years, and that's because, I
5 presume, C-22 is considered to last that long before you get
6 any significant failures.
7 Ten thousand years is a long time and the database
8 for the corrosion of C-22 is not too large and you tend to
9 believe extrapolations like that when you have a good
10 understanding of the basic processes involved as opposed to
11 just measurements. You understand mechanisms.
12 How comfortable are you that you can believe that
13 it will not corrode for 10,000 years? How much do you know
14 about the fundamental corrosion processes of C-22?
15 MR. ANDREWS: Well, I'm probably not the best
16 person -- I'm not a C-22 expert.
17 MR. WYMER: This is fundamentally your whole
18 analysis.
19 MR. ANDREWS: Well, in the first 10,000 years, for
20 the nominal scenario class, yes, the degradation
21 characteristics of that waste package and the welds and the
22 stresses at the welds are what dominate the performance.
23 The analysis and model reports and the data and their
24 justification incorporating the uncertainty, and there is
25 uncertainty in the degradation characteristics, there is

1 uncertainty in the stress stage at the welds, there is
2 uncertainty in other mechanisms, other process mechanisms
3 that can lead to degradation of those engineered materials,
4 all of those are in the analysis model reports, plus a
5 description of their uncertainties and their basis.
6 In order to evaluate kind of the what if sort of
7 scenario that you're alluding to, I think, is we've done
8 several things. One, that I'm going to get to here in a
9 second, is that we looked at this barrier, as a barrier, and
10 looked at all of the component parts of that barrier that,
11 first off, are included.
12 So the things that we have included and their
13 uncertainty and pushed them to their -- all of the key ones
14 to their 95th percentile in order to see what happens, if
15 you will. That's one thing that we've done.
16 The other thing we've done is we've done, in
17 support of the repository safety strategy, we've done -- and
18 looking at this potential vulnerability, we've looked at
19 juvenile failures, quote-unquote, juvenile failure of the
20 package, and then done the same analyses off of those
21 juvenile failure packages that we've done for the nominal
22 packages.
23 MR. WYMER: Where you assume a limited number of
24 failures.
25 MR. ANDREWS: Right, assume a number have failed.

1 They fail with a patch kind of opening under a drip shield
2 and then we've sometimes failed the drip shield and the
3 package at the same time, just to gain an understanding for
4 how the system performs in the absence of that barrier, if
5 you will.
6 The other thing, of course, that we've done is --
7 MR. WYMER: What results do you get when you do
8 that?
9 MR. ANDREWS: Those are -- for a singular -- I
10 don't have them, at the top of my head. They're in the
11 document that's undergoing review right now. My
12 recollection is for a single package, it was, at 10,000
13 years, it was on the order of ten-to-the-minus-two or
14 ten-to-the-minus-three millirems for a package.
15 Abe, do you remember what the numbers were?
16 MR. VAN LUIK: I don't, but it sounds about right.
17 MR. ANDREWS: It's in that ballpark, anyway.
18 MR. WYMER: Okay. Thanks.
19 MR. GARRICK: While we're on that curve, which is
20 a very interesting one, given that the igneous event is now
21 controlling the risk through the time of compliance, does
22 that not bring up the whole issue of the design of the
23 repository in terms of how much you should invest in trying
24 to design a 12,000 year waste package? In other words,
25 aren't you in a situation here with a much more conventional

1 waste package wouldn't change the risk?

2 MR. ANDREWS: Well, if I had a much more

3 conventional waste package, I'm not sure that line on the

4 right would start appearing after 10,000 years.

5 MR. GARRICK: No, it wouldn't.

6 MR. ANDREWS: It would be significantly before.

7 MR. GARRICK: That's the point. It doesn't

8 matter.

9 MR. ANDREWS: For this.

10 MR. GARRICK: If you moved everything -- yes.

11 MR. ANDREWS: If I moved it significantly to the

12 left.

13 MR. GARRICK: It doesn't matter from a risk

14 perspective. You could get by with a lot less extravagant

15 repository design. Given that the risk is being driven by

16 something that you can't design out.

17 MR. ANDREWS: It's possible.

18 MR. GARRICK: Just something to think about. It

19 seems to me, as far as my paying for this, from a risk

20 standpoint, I'm paying a heck of a lot money, perhaps,

21 perhaps if the calculations haven't been done, to achieve a

22 level of performance that, from a risk perspective, is kind

23 of irrelevant.

24 MR. ANDREWS: I agree and that's very possible,

25 and I think Abe alluded to some design related sensitivity

1 analyses that are to be done. Right now, we have close to a
2 point design. It's a flexible design, but it's close to a
3 point design.
4 We are, this fall, probably going to do some
5 limited simplifications of that design, just to see what if,
6 I think to address questions like that.
7 Having done that, that's one step of performance
8 assessment, generating the curve and a series of curves.
9 Another, and, in fact, as important, maybe even more
10 important aspect of it is to evaluate why those curves are
11 the way they are.
12 Do the sensitivity analyses, do the statistical
13 analyses, do the barrier importance analyses, to gain an
14 understanding of what's going on and why is it going on.
15 So there's been a wide suite of these done in
16 support of the SRCR, first, and documented in the technical
17 report and documented in the repository safety strategy.
18 These start first off with basic statistical
19 evaluations, what drove the variance, what drove the mean,
20 what drove the top ten percentile, et cetera. There's a
21 wide variety of statistical techniques available and we've
22 used the ones that are most appropriate for our intended
23 purpose.
24 We've done then a large number of sensitivity
25 analyses, taking an individual factor, an individual

1 parameter and doing 95th-5th percentile sensitivity analyses
2 on that factor or parameter, trying to gain an
3 understanding, by factor, what is its contribution to the
4 system performance, always running out to the 100,000 year
5 time period.
6 Why 100,000 years? Well, 100,000 years was to go
7 sufficiently beyond 10,000 years to the point where the
8 engineered barriers were degrading, go sufficiently beyond
9 10,000 years to assure ourselves and the reviewers that
10 there was no significant degradation of any aspect of the
11 system beyond the 10,000 year regulatory time period.
12 So all the sensitivity analyses and barrier
13 importance analyses are also done out to 100,000 years, with
14 the exception of that 50,000 year volcanic event one.
15 The final set are what we've termed barrier
16 importance analyses and those are going barrier by barrier
17 and looking at, in two different ways, looking at either 5th
18 or 95th percentiles of the key aspects of that barrier, 5th
19 being on the good side of performance, 95th being on the bad
20 side of performance.
21 If that particular parameter, a low value, meant
22 bad performance, then we flipped it. So it's looking at
23 good or bad within the distributions that we have.
24 Finally, the last bullet there is in some cases,
25 for particular barriers, they were neutralized; i.e., the

1 function of that barrier was removed from the analysis to
2 evaluate the contribution of that barrier and all the other
3 barriers to the system performance.
4 Those were mostly used in support of the
5 defense-in-depth and multiple barrier determinations that
6 are embodied in the repository safety strategy.
7 The next three -- I'm going to go a little faster
8 here -- slides just talk through using the same orientation
9 I did in the previous table, which is the same table that's
10 in the back of the document, go through what's the barrier,
11 what's the barrier function, and what was the importance
12 analysis done on that barrier, where that performance
13 analysis here was that 95th-5th percentile aspect.
14 So you can read what aspects of the system were pushed to
15 their limits in that particular table.
16 The next slide, which is a results slide, walks
17 through some regression analyses, and these are supported in
18 a lot of different ways. I'm just showing you the
19 regression analyses of the nominal performance scenario to
20 what drove the variance.
21 So I'm trying to understand what drove that
22 six-eight orders of magnitude of variance of system response
23 for all of the uncertainty inputs that were put in there.
24 I think Abe already alluded to this one, but the
25 top four relate to the package. They relate to the welds of

1 the package and they relate to essentially stress corrosion
2 cracking at the welds of the package.
3 So that is a point of continued investigation,
4 continued discussion. I believe this issue came up,
5 although I was not able to attend, at the container life and
6 source term KTI meeting, about the importance of the stress
7 state at the welds and degradation mechanisms at the welds,
8 which includes the defects at the welds.
9 The other one is the saturated zone flux.
10 Having done that, it points to a few parameters of
11 the several hundred that are in the total system model to do
12 a barrier importance analysis on.
13 The next slide, the results slide, John, if you'd
14 just slip to that one, assumed -- you know, I took 95th
15 percentiles and 5th percentiles of those stress factors,
16 those corrosion rates, the defect distribution, the defect
17 orientation, the defect size, all of which are parameters in
18 the TSPA model, and pushed them to their 95th percentile,
19 and then ran 100 realizations, we only did 100 when we were
20 doing barrier importance analyses, 100 realizations and redo
21 a mean or expected value off of those 100 realizations.
22 And you can see that if we sample some of those
23 parameters at their close to extreme values, obviously not
24 the 99th percentile, but at their 95th percentile, we
25 generate early failures and when we generate early failures,

1 we get early releases through those stress cracks at the
2 welds.
3 These are all driven by the weld and degradation
4 at the weld and those are early and prior to 10,000 years.
5 With that, I have a few slides to just summarize,
6 but they more or less repeat what Abe had, first talking
7 about the major technical improvements and the major process
8 improvements and then, finally, summarize with where we are.
9 As I've said, the results are done, but in
10 checking and review, the document has not been delivered to
11 the Department of Energy yet for their acceptance. They
12 will, of course, do an acceptance review and we'll make
13 whatever changes in the document, in the analyses, in the
14 report as required, as they did with all the process model
15 reports.
16 So with that, I'll entertain any questions you
17 might have.
18 MR. GARRICK: Good. Thank you. Thank you very
19 much. That's a very interesting presentation.
20 Committee, any comments? Milt?
21 MR. LEVENSON: I had one comment, or a couple, on
22 the same issue. You discussed the degradation of the waste
23 container and it was very clear and I think probably is what
24 happens. You get a crack in a weld and et cetera.
25 But unfortunately, in one of the pieces of paper

1 we got a month or two ago, it said that the assumption was
2 made that when the container lost the ability to be helium
3 leak-tight, the assumption was made that 50 percent of the
4 container disappeared.
5 Now, that's quite in contrast to what you've said
6 and I can't give you the specific reference, but I know the
7 other committee members have read the same thing. So I was
8 a little -- what you're telling us is what's really in the
9 TSPA.
10 MR. ANDREWS: I don't know this helium leak test
11 issue.
12 MR. LEVENSON: Well, the problem is when -- that
13 they assumed when failure occurred, when it cracked through,
14 the 50 percent of the container disappeared, so the fuel was
15 immediately immersed.
16 MR. ANDREWS: No. I do believe -- well, I don't
17 know where that -- if it was a criticality -- that sounds
18 like an extreme assumption for criticality analysis
19 purposes, but I have no idea if that's the case.
20 MR. LEVENSON: It was supposed to be release. The
21 other question I have, which is somewhat related, is that
22 even at 10,000 or 15,000 years or whatever time we want, the
23 fuel is really the only heat source in the mountain and,
24 therefore, if humid air gets through a crack, why would you
25 expect condensation on what is the warmest thing in the

1 mountain?

2 MR. ANDREWS: That was one of those -- I think I

3 alluded to it, maybe not as directly as your question is

4 pointing out. The innards of the package and the hydrology,

5 other than the temperature, the hydrology and chemistry of

6 those innards of the package, that was simplified and

7 conservatively so for this particular iteration of the PA.

8 There have been analyses, supporting analyses of

9 the amount of heat that the waste form, in particular, the

10 commercial spent nuclear fuel waste forms.

11 This is not so much an issue with the glass or the

12 DOE spent nuclear fuel, which are much, much, much cooler.

13 The heat output is much smaller in those packages.

14 But for the commercial fuel, your point is well

15 taken and there are some analyses that talk about more or

16 less an eight to 15,000 year time period, the time period is

17 a function of burn-up and age-out of reactor and storage and

18 things like that.

19 One would expect the system that you just

20 described to occur, that the water, humid air, would never

21 condense on the waste form itself during that kind of time

22 period because of the heat that's being generated.

23 After that time period, the temperatures are so

24 evenly distributed across all aspects of the waste form, the

25 package, the innards, the basket materials, et cetera, that

1 taking any more credit beyond that time period would not be
2 very feasible.
3 MR. LEVENSON: Because there is no time period
4 that you can go to when the fuel is colder than the
5 mountain.
6 MR. ANDREWS: That's true, that's true.
7 MR. GARRICK: Ray?
8 MR. WYMER: No, I've said my piece.
9 MR. HORNBERGER: Bob, Abe was -- we got into that
10 discussion about the qualified -- I think you called it
11 qualified uncertainties, the issues that you were just
12 discussing.
13 How will you work that in after you do these
14 analyses? Do you have any idea how you'll work that into
15 the presentation? I mean, the idea would be, on some of the
16 issues, the kind that Milt was just referring to. These are
17 one-sided. So they're not symmetric.
18 MR. ANDREWS: There's a large number of them that
19 are not symmetric. Given that we've -- in fact, most of
20 them are probably not symmetric. We made -- and not just PA
21 doing the final crank turning, but we, the project, in these
22 various areas where those assumptions were made, made that
23 conscious decision to be on the conservative side of a
24 distribution.
25 Doing -- so that means we're on the -- whichever

1 side is conservative, I don't know if that's right or left,
2 but we're on the right side of the distribution and
3 everything is to the left side of that distribution, in
4 which case putting in the whole distribution, if it's
5 distribution, or alternatives, A/B kind of alternatives,
6 means we're pushing it to the left, pushing it to lower
7 doses, if you will.
8 And they'll probably be treated as sensitivity
9 analyses off of what we say here is a conservative
10 representation of how we think this system will evolve.
11 So there will probably be, in terms of the
12 documentation, and we haven't discussed this with the
13 department and they might have different ideas, and so Abe
14 probably should say something, but we probably would put it
15 into this alternative model representation.
16 The other alternative, of course, is -- maybe I
17 shouldn't go here, but we have EPA and NRC have slightly
18 different definitions that go after the word reasonable.
19 One talks about reasonable expectation, one talks
20 about reasonable assurance. It may very well be that some
21 of these issues that we're talking about fall into the
22 reasonable expectation kind of case, rather than a
23 reasonable assurance case where you really want very high
24 defensibility of your models and assumptions before you go
25 forward with a license.

1 And that kind of discussion is going on right now
2 within the department, but whether it's a sensitivity
3 analyses, whether you use it in this reasonable expectation,
4 whether they are used for peak dose kind of considerations.
5 You've been conservative during the time of
6 regulatory concern and let's say appropriately conservative
7 during the time period of regulatory concern, but after the
8 time period of regulatory concern, when you're looking at
9 geologic stability timeframes, perhaps you should put this
10 reasonable expectation argument in.
11 It's for the final environmental impact statement,
12 which, of course, goes along with the license application,
13 but it's serving a different purpose. Those peak doses are
14 serving a different purpose for a different audience.
15 Maybe that's an idea. I don't know. Abe, do you
16 want to -- it's kind of a policy question.
17 MR. VAN LUIK: It's a policy question, but I think
18 your answer was correct. We were discussing exactly that
19 issue.
20 MR. GARRICK: Abe, can you go to the mic and
21 repeat that?
22 MR. VAN LUIK: Your discussion is essentially, in
23 a nutshell, what we are trying to determine within the
24 department should be our approach between the case that will
25 actually evolve into the licensing case and also the larger

1 case for the peak dose, which is to satisfy NEPA and satisfy
2 197's reasonable expectation.
3 And they go out of their way to say that what
4 we're interested in is what you expect, the expected value
5 case, that they're not interested in details of our
6 distributions for that particular purpose.
7 So that's some of the internal discussions that
8 we're having and we'll make a decision on how that goes
9 forward before the time of SR.
10 But what you will see in the SRCR is basically
11 what Bob has shown you.
12 MR. HORNBERGER: Second question, Bob. Can you
13 summarize for me how information, let's say, derived from
14 analog studies makes its way into the TSPA analysis or is
15 that considered separate from the TSPA?
16 MR. ANDREWS: There's a couple of ways. That's a
17 good question. A lot of it, and most of the time, it's
18 confirmatory type information to lend support to the process
19 models that are the underpinning analysis model reports.
20 Most of the time, it's that, to help defend, if
21 you will, the quote-unquote, validity of those process
22 models.
23 So in that sense, it's not a direct parameter or
24 direct data set that's fed into PA.
25 There are examples where those analogs, in

1 addition to providing support, actually are used to support
2 some of the data. It's non-site data, not DOE data, but
3 literature, available information that's relevant and
4 applicable to be applied.
5 So it's incorporated within the process model
6 itself as a -- if you will, down at the process model, a
7 direct feed. By the time we see it in PA, by the time it's
8 gone through an abstraction and incorporation into the TSPA,
9 you probably have lost a little bit of that direct
10 one-to-one traceability from that data set, that analog data
11 set into the process model and through the process model
12 into the TSPA, but it's there.
13 So it's confirmatory for most of the cases, kind
14 of add confidence, confidence-builder.
15 MR. GARRICK: The committee has a lot of questions
16 that they would like to explore one day on the TSPA and I
17 think we're going to have to do that at a later time and
18 when we get down to maybe a lower level of the analysis.
19 I think this has been an excellent overview.
20 There's a great deal of interest here in how some of these
21 algorithms are actually applied and how some of the analysis
22 is done, and we'll look forward to covering those in other
23 meetings as we get more involved in the PMRs and the AMRs
24 and the input documents into the TSPA.
25 So we'll look -- and I have a lot of questions,

1 but we'll look to another time to do that.

2 I've had requests from two people. Andy, you have

3 a question? Go ahead, I'm sorry.

4 MR. CAMPBELL: Just a quick one, Bob. Do you

5 feel, does the program feel that in the transition from

6 TSPA-VA to TSPA-SR, the modeling and the approaches and what

7 gets incorporated into the models in terms of parameters has

8 become more conservative or do you think it's become a

9 little more realistic?

10 MR. ANDREWS: I think, in toto, it's become more

11 realistic. There's the few examples where a conservative --

12 if a conservative assumption was made in the SR, it was

13 probably also being made in the VA.

14 MR. CAMPBELL: The reason I ask is it looks like

15 the dose curves have increased. At any one time, you get

16 higher doses in the TSPA-SR by, in some cases, almost a

17 factor of ten, if you look at the mean or the 95th

18 percentile.

19 If you're becoming less conservative, shouldn't

20 the doses be going down?

21 MR. ANDREWS: No, more realistic.

22 MR. CAMPBELL: If you're becoming more realistic.

23 MR. ANDREWS: I think the one aspect of the system

24 that's driving -- or a significant difference that drives

25 that is the solubility distribution, in particular, for

1 neptunium, because neptunium is what's driving the 100,000
2 year and, in fact, the peak dose.
3 In the VA, we tried to broaden that uncertainty to
4 incorporate both the waste form degradation characteristics
5 and the data from Argonne and PNL and Livermore, but mostly
6 from Argonne, as well as the direct observations of
7 solubility from Los Alamos and Berkeley.
8 So we had all the labs doing varying parts of
9 neptunium solubility work, which made it a fairly broad
10 distribution, had some lower values, had a few higher, but
11 mostly, on toto, was lower than what we have in the SR.
12 There were comments on the VA saying make the
13 solubility more chemistry dependent and we made the
14 solubility more chemistry dependent.
15 And in those analyses and model reports that
16 relate to the chemistry dependence of neptunium solubility,
17 the currently available data and fundamental thermodynamic
18 data pointed to a very strong pH. dependency which is
19 incorporated in the model, which meant, by doing so, the
20 solubilities ultimately were increased from what we had in
21 the VA.
22 So I think it's reasonable, defensible, but higher
23 value.
24 MR. LEVENSON: As a follow-up question, I
25 understand the technetium solubility is from real data.

1 What about technetium retention as it moves through the
2 ground? There is an assumption that is not related to, I
3 think, experimental data.
4 MR. ANDREWS: Now, there are technetium, neptunium
5 and technetium, there are retardation data for both of them
6 from Los Alamos, with site-specific kinds of materials.
7 The technetium retention in the alluvium is being
8 considered in the TSPA-SR, as is neptunium retention through
9 the whole system is being considered in the TSPA-SR, based
10 on best available data on those retention characteristics.
11 So if they're retarded, they're with data that
12 support them, they are in there.
13 MR. GARRICK: Okay. Speaking of intrusion, we're
14 getting into our lunch period. But as I was about to say,
15 we've had two people ask for an opportunity to make a few
16 comments and I would like to get those in and I would like
17 to limit the comments to three to five minutes.
18 Is Mr. Harney here? He's not here. All right.
19 Then Judy. Judy Treichel, of the Nevada Nuclear Waste Task
20 Force, would like to make a comment.
21 MS. TREICHEL: Judy Treichel, Nevada Nuclear Waste
22 Task Force.
23 You said that you were coming here so that you
24 could hear from us and I want to find out how that works,
25 because you are hearing.

1 I've got questions on the pyramid that I guess you
2 have in color and the rest of us got in black and white,
3 that shows the -- where we're at and where we're going and
4 all of that sort of thing.
5 I want to know, because the SRCR is supposed to be
6 a featured event in our lives very soon, how big is that?
7 Are we talking telephone book, something like this, are we
8 talking site characterization plan? How tall is that thing
9 expected to be? It's two volumes.
10 MR. SCOTT: I believe it's about 1,300 to 1,400
11 pages.
12 MR. GARRICK: You're going to have to use a
13 microphone and announce who you are.
14 MR. SCOTT: Mike Scott, M&O. I believe Tim
15 Sullivan, with DOE, said this morning it would be about
16 1,400 pages.
17 MS. TREICHEL: Okay. So probably about like the
18 draft EIS. Then am I correct that when the site
19 characterization -- when the site recommendation report
20 itself comes out, you just slap two additional volumes on
21 there? Those first two go as they are and you put two more,
22 or are you going to rewrite the first two?
23 Here's one and two, and then three and four come
24 in. Does all of this in this hunk stay the same or are you
25 making changes before you go to the Secretary and the

1 President, after we've had our chance to comment?
2 MR. VAN LUIK: The idea is that we would actually
3 listen to the comments, consider them, and make changes in
4 the documents before they go to the Secretary.
5 MS. TREICHEL: So it's up to us to get this site
6 recommendation all ready to go, because you were asked if it
7 was going to be reviewed and it appeared that was kind of
8 iffy and you weren't too sure about that.
9 MR. VAN LUIK: Ninety days.
10 MS. TREICHEL: For us.
11 MR. VAN LUIK: Uh-huh.
12 MS. TREICHEL: And that's interesting, too,
13 because during those 90 days, which, of course, we're pretty
14 used to, you have all of the major holidays and you still
15 got -- and we -- and in addition, we have no EPA rule, we
16 have no NRC rule, we have no DOE guideline.
17 So I'm not sure why, if we were doing a bona fide
18 job of reviewing this thing, we wouldn't review it against
19 the existing rules, that we wouldn't just take 60, we
20 wouldn't take 960 and see if it passes muster, because
21 that's what's there. We won't have anything new.
22 At the same time, while we're doing this exercise,
23 we're going to have eight technical exchanges that are going
24 on that are trying to bring about sort of resolution or
25 clarification or whatever you want to call it, changing the

1 status of your KTIs and the questions that people have.
2 So those are going on and we do those all at the
3 same time. In addition, the other myriad of meetings that
4 happened in which everything changes.
5 There was information you got today from DOE
6 that's a little bit different than what we've seen before
7 and the design is always different in one degree or another.
8 It was a little different today because of a difference in
9 the stainless steel part of the package. And we know that
10 that's not going to get frozen.
11 So I guess what I'm trying to figure out is
12 whether or not I'm spinning my wheels. The public doesn't
13 get paid. So we have to kind of save on what we spend, and
14 that includes our energy. And I just don't want to wind up
15 out there with something that means nothing, and maybe
16 there's other more important things going on.
17 So thank you for listening.
18 MR. GARRICK: Thank you. Thank you very much.
19 All right. Unless there's comments from anybody, I think we
20 will adjourn for lunch. Try to be back here as close to
21 1:00 as possible.
22 [Whereupon, at 12:05 p.m., the meeting was
23 recessed, to reconvene this same day at 1:00 p.m.]
24
25

1 AFTERNOON SESSION

2 [1:05 p.m.]

3 MR. GARRICK: We'd like our meeting to come to
4 order. For the benefit of those on the panel or on the
5 committee that are chemically inclined, this is their time
6 to shine.

7 We're going to, this afternoon, spend a good deal
8 of time on chemical related issues and to actually lead the
9 discussion and questioning on this will be Dr. Wymer.

10 Our first speaker is going to be Dr. William
11 Boyle, and I think, unless there's anybody that wants to
12 make any preliminary comments, we'll get right into it.

13 MR. BOYLE: Good afternoon and thank you for this
14 opportunity. You can see the names on the sheet here. I'll
15 be very brief and just mainly provide an introduction as to
16 why DOE wanted to make these other measurements of
17 chlorine-36.

18 I will be followed by Dr. Mark Peters, of Los
19 Alamos, who will provide the technical details, and the
20 actual work is being done by the principal investigators who
21 are listed at the bottom, most of whom are here, Mark Caffee
22 from Livermore is here, June Fabryka-Martin from Los Alamos
23 is here, Mel Gascogne from AECL is not, and Zell Peterman of
24 the USGS is here, and Robert Roback of Los Alamos is here.

25 So if there's questions on the details, the

1 investigators are here.

2 For those of you who were present in Pahrump in

3 May for the NWTRB meeting, I've got the same sheets, so it

4 will be repetitive for you.

5 I assume most of the audience knows why the

6 project has measured chlorine-36, but just in case, I will

7 give a non-expert synopsis.

8 Chlorine-36 is one of many naturally occurring

9 radioisotopes used for age dating. Its abundance was

10 changed my nuclear weapons testing in the South Pacific in

11 the 1950s, creating a bomb pulse.

12 Measurements of chlorine-36 at Yucca Mountain have

13 been interpreted to have this bomb pulse. These bomb pulse

14 data, at depth, are then used as evidence that there are

15 vast flow paths in the unsaturated zone at Yucca Mountain.

16 That's the synopsis, and now I'll go on to why we

17 did the validation measurements.

18 The project's original measurements for

19 chlorine-36 were done by Los Alamos National Lab. As you

20 can see, there are other organizations involved now in the

21 validation measurements.

22 And why were these validation measurements made?

23 Well, about two years ago or even a little bit longer, a

24 series of reports were written by the United States

25 Geological Survey that seemed to describe a comprehensive

1 history over geologic time about the unsaturated zone at
2 Yucca Mountain.
3 This history was based upon the integration of
4 many independent data sets. Not surprisingly, not every
5 data set that was used to develop the integrated history
6 flanged up perfectly.
7 One of the data sets that did not flange up as
8 well as some of the others is the chlorine-36 results from
9 Los Alamos National Lab.
10 In discussions about why there might be this
11 difference between the chlorine-36 data set and the USGS
12 history for Yucca Mountain, it was decided initially to
13 follow a standard scientific practice and have an
14 independent group make measurements of the chlorine-36, and
15 those independent measurements are those by Mark Caffee and
16 the others listed on the sheet, not from Los Alamos.
17 So we went ahead and made the measurements and now
18 you will get to hear the results of those. At this point, I
19 will turn it over to Mark Peters.
20 MR. PETERS: Thanks for having me. I do work for
21 Los Alamos, but I'm really up here as a representative for
22 the team that Bill mentioned is out there in the audience.
23 So I'll go through a lot of the technical details, but I'm
24 hoping to get through it, leave a lot of time for questions,
25 and then the PIs in the audience I've already told to feel

1 free to step up and help me answer some of the details,
2 clarify, however you all want to work that. That's up to
3 you.
4 Bill already mentioned the participants. They're
5 all sitting in the audience today, which is real nice. What
6 I want to do today is walk you through, first, a lot of you
7 are familiar with the chlorine-36 studies that we've done
8 over the past three to four years. I want to bring you back
9 up to speed on what that data set looks like, then go into
10 some of the results from the validation study, where we're
11 doing analyses of samples from some of the locations in the
12 ESF, where we thought we saw bomb pulse, and then bring in
13 some cross drift results and then wrap up with the path
14 forward, because as I'm going to show you, there are some
15 differences in the analyses for chlorine-36 chloride ratios
16 for some of the samples in the ESF set of samples from the
17 Sundance fault and we have a path forward that we're
18 following to try to address those differences.
19 As I'm going through, I want to clarify, so we
20 don't get lost in semantics. I'm going to be talking a lot
21 about sampling, processing, and analysis.
22 When I mean sampling, I mean physically taking the
23 sample from the rock and then processing, I mean what we
24 have to go through in the laboratory to process the sample,
25 fairly labor intensive, and then the analysis is done by

1 accelerator; in the case of Livermore, at Livermore; in the
2 case of Los Alamos, it's sent to Purdue University.
3 So, first -- and I should also say that there's a
4 lot of organization-specific references. You'll see a lot
5 of Los Alamos and Livermore. We are working as a team, but
6 it helps me distinguish between the data sets to point that
7 out. So this is an integrated study that we're carrying
8 forward with.
9 In terms of the overall objectives of the
10 chlorine-36 chloride program over the past three to four
11 years, the objectives are shown here. We were looking to
12 test alternative conceptual models for unsaturated zone flow
13 and transport.
14 Specifically, to look at flow and transport through the
15 Paintbrush tuff, the Paintbrush, non-welded, which sits
16 stratographically above the repository horizon.
17 Then also to look at the significance of differing
18 temporal and spatial scales. And what I mean by that is the
19 effects of episodic infiltration and how well the PTN might
20 dampen that flow into the repository horizon.
21 The program focused on systematic samples. Parts
22 of the ESF, we took samples every 100 meters, and then in
23 some cases, every 200 meters. We also looked at features,
24 meaning fault zone fracture sets and took samples, and there
25 we were taking block samples, large samples, with a pick

1 hammer or jackhammer, taking those back to the laboratory.
2 Bill mentioned the validation study. In the
3 validation study, we were focused -- and I'll show you the
4 data from the ESF in a minute, but one of the locations in
5 the ESF that we saw apparent bomb pulse was in the Sundance
6 fault zone. I'll show that on a map, but it sits down in
7 the main run of the ESF, down by Alcove 6, for those of you
8 who are familiar with the ESF.
9 We took -- and also at the drill hole wash fault,
10 but I'll talk mainly about the data from the Sundance today.
11 Those samples were taken by drill. We did bore
12 holes. So there was a difference in sampling approach for
13 the validation study than in the studies that we've been
14 doing over the program in the past couple of years.
15 Again, it was led by the USGS, with involvement of
16 Los Alamos, Livermore and AECL.
17 We were also looking at some of the samples, in
18 addition to looking at chloride-36, chloride measurements.
19 WE also have some tritium analyses that I will talk about
20 briefly.
21 But what we did is we did systematic bore holes
22 across those two fault zones, two-inch cores, up to four
23 meters, and, again, to emphasize, it was in contrast to the
24 sampling approaches that we took in the ESF and in the cross
25 drift.

1 So we took samples as depth slices and splits were
2 taken. So in some cases, we have Livermore and Los Alamos
3 looking at some were core and some were hole.
4 I mentioned I want to talk about the cross drift.
5 I call this validation, maybe I should put it in quotes, but
6 nonetheless, in the cross drift, we also did feature-based
7 sampling, but here we were able to do predictions using the
8 UZ flow and transport model for what we thought we would see
9 in terms of chlorine-36 chloride systematics and we compared
10 those predictions.
11 So background for chlorine-36, Bill alluded to it
12 to some extent. Chlorine, this is basically lifted out of
13 the table already, nuclides, chlorine-35, chlorine-37, both
14 stable isotopes, make up the full abundance. Chlorine-36
15 has a half-life of 301,000 years.
16 In terms of sources in the subsurface, you've
17 really got three primary sources. You have the pre-bomb
18 ratio, the modern ratio is about 500-ten-to-the-minus-15.
19 That has varied through time due to variation in the field
20 strength, the magnetic field strength on the earth, you get
21 more or less cosmic ray bombardment, therefore, more or less
22 chlorine-36 production in the atmosphere that rains down.
23 B bomb pulse has a much higher ratio. Then C,
24 there's a contribution from production of it due to
25 reactions, nuclear reactions with uranium and thorium in the

1 subsurface.

2 That ratio is much lower, 20 to

3 50-times-ten-to-the-minus-15, and that tends to be a

4 negligible contribution. All in all, those three sources,

5 there are some other minor sources, but they add up to what

6 you see in the subsurface rocks and water and what we then

7 measure.

8 Now, to go back to what we've seen in the ESF, the

9 exploratory studies facility. This plot is on the Y.

10 Chlorine-36, the chloride ratio, times-ten-to-the-minus-15,

11 has a function of construction stations, so that's thousands

12 of meters through the ESF. The north ramp, the main drift

13 and the south ramp are shown along the top.

14 There are several different kinds of samples shown

15 here. This is the Los Alamos results. So you have, in the

16 black squares, you have the systematic samples. The open

17 squares are the feature-based samples, then there's also

18 core water samples, where we've done -- we've extracted

19 water using centrifuge and done analyses of that water.

20 Then there is also plotted on here, in the red are

21 the Los Alamos validation samples, meaning the splits of the

22 core from the validation work at the Sundance.

23 But you can see, in general, where we see apparent

24 bomb pulse ratios, which were above

25 1,200-ten-to-the-minus-15. It tends to be associated with

1 structural features.

2 So we chose the Sundance and the Drill Hole Wash

3 to do our systematic validation study across there.

4 So just to come back to the validation work. The

5 goal here was to verify the presence of bomb pulse in

6 samples taken from the ESF and the sample preparation method

7 that was developed, that Livermore is using, is designed to

8 detect the presence of bomb pulse. So we weren't looking to

9 delineate the relative contributions from those three

10 sources, but we were mainly looking for any evidence of bomb

11 pulse chlorine-36 in ESF.

12 This is the data for the Livermore results.

13 Again, we did a series of bore holes across the Sundance

14 fault. This is chlorine-36 to chloride

15 times-ten-to-the-minus-15 on the Y; again, plotted against

16 ESF station.

17 We did a series -- we did on the order of over 40

18 bore holes across the structure and you can see the data

19 there. So the present day ratio is shown about

20 500-ten-to-the-minus-15, ratios greater than 1,200,

21 indicative of bomb pulse.

22 You can see the Livermore analyses are all

23 relatively low, in the 50 to 200-times-ten-to-the-minus-15

24 range. No evidence of bomb pulse.

25 Now, for the Los Alamos results from the

1 validation study. This is, again, a similar plot, same
2 ratio plotted on the Y against ESF station, with the
3 Sundance fault drawn in the -- the Sundance is right here.
4 And here is the sampling interval. WE sampled across the
5 fault with the bore holes.
6 What's plotted here in the blue diamonds is data
7 from the -- what I'll call the standard ESF study and then
8 in the red squares are the validation results from Los
9 Alamos.
10 We haven't seen evidence -- we haven't seen ratios
11 greater than 1,200, but notice there is a difference. All
12 the samples are greater than 500-ten-to-the-minus-15, so
13 you've got a significant difference in ratio there between
14 what Livermore was getting for similar samples.
15 You have to ask yourself, okay, what -- well,
16 that's really the crux of why we're here. We've got two
17 data sets now that are showing some differences. How robust
18 are the Livermore data? When you correct for blanks, you
19 don't really affect the final ratio. In general, when you
20 correct the ratios for things, you tend to lower rather than
21 raise the ratio.
22 However, and I will talk more about this, if you
23 correct for rock chloride, which might be related to sample
24 processing, processing in the laboratory, it may be possible
25 that you could cause the correction to go in the other

1 direction, but that's what we're about in our path forward
2 trying to figure out what's really going on, particularly in
3 the processing techniques. That may be part of the
4 differences.
5 But I should also mention the Livermore --
6 Livermore runs samples from all over the world for a lot of
7 different reasons and when the samples that were run at the
8 same timeframe yielded results that were consistent with
9 what they expected for the geologic setting.
10 So we have no reason to believe that the Livermore
11 data is wrong or the Los Alamos data is wrong. We need to
12 look into the details of how we process the samples.
13 MR. GARRICK: Were the sampling procedures exactly
14 the same?
15 MR. PETERS: Do you mean sampling in the field or
16 processing in the laboratory?
17 MR. GARRICK: I mean in the field.
18 MR. PETERS: Yes. It was taken from the same bore
19 hole. So they were dry drill bore holes and then the core
20 was simply split for the validation study.
21 MR. GARRICK: And were they governed by any kind
22 of a national or international standard for taking such
23 samples?
24 MR. PETERS: They were collected, according to our
25 QA program, like we sampled all the samples underground. So

1 it's proceduralized.

2 MR. GARRICK: They both used the same QA program.

3 MR. PETERS: The collection in the field was the

4 same program, because it was the same driller, same drill

5 rig, same sample handlers.

6 So where we're headed here is how one -- what's

7 going on downstream of that.

8 MR. GARRICK: And those same questions we'll want

9 to talk about downstream.

10 MR. PETERS: Right. And the details of that are

11 better spoken to by the PIs. I'm not going to say a whole

12 lot more than what I've already said, actually. But we do

13 have a path forward that focuses on that part of the process

14 to see if that's -- that therein lies the difference.

15 I mentioned at the beginning that we're looking --

16 there's some related work associated with the validation

17 study. For example, we're also looking at doing tritium

18 analysis in some of the same samples, and here we're

19 extracting the water and doing tritium analyses.

20 This is a slightly out-of-date slide. The USGS

21 has done additional analyses, but suffice it to say it

22 doesn't change the distribution.

23 So right now we've seen really only one sample

24 that's even above detection limit for tritium.

25 So for the validation samples, no events of bomb

1 pulse tritium. But tritium and chlorine-36 are going to act
2 very differently in the unsaturated zone hydrologic system.
3 MR. HORNBERGER: Is the processing for tritium
4 similar to the processing for chlorine-36?
5 MR. PETERS: The tritium was all through
6 centrifuge. You extracted the water with the centrifuge --
7 distillation, excuse me. So vacuum distillation. So
8 basically putting -- moving it around in a cold trap in a
9 vacuum line, basically, whereas chlorine-36, as you know, is
10 basically running DI through some variation on that theme.
11 AECL's participation is mainly focused on the
12 U-series disequilibria work that they're doing. This
13 doesn't -- it speaks a lot to the -- basically, the
14 residence time of core water in the unsaturated zone. It
15 doesn't speak as much to bomb pulse, but it combines real
16 nice in with geochemical indicators of long-term percolation
17 flux, et cetera.
18 But we are seeing that thorium, uranium and radium
19 are in secular equilibrium. Therefore, they haven't been
20 moving around over the past 100,000 years.
21 The 234-238 uranium ratios are depleted, show a
22 five percent depletion in uranium-234, which suggests that
23 uranium-234 may be lost to pore fluids and that's probably
24 by alpha recoil.
25 And therefore, we would expect the pore fluids to

1 be enriched in 234, and they, in fact, are. So that can
2 actually be modeled to give us an idea of residence time of
3 the core water in the unsaturated zone.
4 Now, getting back to the differences. We haven't
5 finished. As Bill mentioned, it's a work in progress. It
6 is a work in progress. It's going to continue next year.
7 Livermore may yet see bomb pulse in some of the samples.
8 Mark made this point in May, and it's a good one.
9 Work to date hasn't demonstrated its absence. We just
10 simply haven't found it. It could be that we may find it.
11 The Livermore sample processing may have selected
12 phases that don't contain bomb pulse chlorine-36 or maybe
13 the samples may not, in fact, have bomb pulse chlorine-36 in
14 them.
15 But at any rate, the chlorine-36 concentrations
16 seem to be comparable, but the difference in ratios may be
17 due to, and this is a may, this is what we're going after,
18 elevated concentrations, chlorine concentrations, because
19 obviously we're reporting chlorine-36 to chloride ratios, so
20 you can -- there's a lot of leverage with chloride
21 concentration there to change that ratio pretty
22 dramatically.
23 So the differences, again, may be related to
24 processing method. We're focusing on that, not sampling or
25 analytical methods. So sample crushing, how you extract the

1 chloride for analysis, and those kinds of things.

2 I've mentioned, we've talked mostly about the ESF,

3 but this data, I don't think you've probably seen this data

4 in a meeting. This is data from the cross drift; again,

5 same ratio along the Y for the cross drift station in 100

6 meter increments, and the same familiar dotted line bounds

7 the range of current day values for chlorine-36 to chloride

8 ratios.

9 There's the faults noted in the cross drift, as

10 mapped in the cross drift, and you can see there, again, and

11 these are back to taking feature-based block samples through

12 the cross drift, so back to the standard ESF program, and

13 it's consistent with what we've seen throughout the ESF,

14 that Los Alamos has seen throughout the ESF.

15 So really what we're focusing in on is why are we

16 getting the differences in the validation samples.

17 So I've already said this, but we did do a set of

18 predictions for the cross drift and, in general, they were

19 consistent with the predictions for where we would see

20 background levels and where we would see bomb pulse.

21 And I said the second bullet already, but the

22 sampling protocol that we use in the cross drift seems to --

23 it does yield similar results to what see in the ESF

24 investigations, except for the validation study, as we've

25 talked about a lot.

1 So what about a path forward? There was a lot of
2 discussion amongst the PIs in the April-May timeframe,
3 particularly after the interactions with the TRB about how
4 to go forward and address these differences.
5 So the path forward is the USGS has prepared a
6 reference sample. We've taken some muck from the cross
7 drift excavations that we were doing back in that timeframe.
8 That's been crushed, homogenized, and then aliquots have
9 been distributed to both Livermore and Los Alamos.
10 There's going to be a set of experiments done by
11 both laboratories to test for the effects of different
12 leaching procedures on the release of rock chloride, again,
13 the chloride could be the key. That's ongoing. So this is
14 really, again, a progress report.
15 We will then do the laboratory work, do the
16 accelerator analyses and see where we're at, compare notes.
17 Once we've sort of agreed on a standard processing
18 method, we hope there will be exchange of samples, exchange
19 of information, apply that to the reference sample and the
20 validation samples, and then the results will be
21 synthesized.
22 Now, I haven't talked too much about the
23 conceptual model, but the ESF and cross drift data, except
24 for the validation data, has been incorporated into our
25 thinking on conceptual models for unsaturated zone flow and

1 transport.

2 So depending upon which way things go with the

3 validation samples, that could have implications for our

4 understanding of the conceptual model.

5 The three bullets are meant to address the aspects

6 of the conceptual model that will be under discussion,

7 depending upon the results of that study, frequency of fast

8 flow paths, roles of fault and fractures, particularly ones

9 that cut through the PTN, the non-welded unit above the

10 repository horizon, and then, finally, pore water ages and

11 implications for infiltration and percolation. The chloride

12 data is also very key. That's used heavily as a calibration

13 tool for the flow field in the unsaturated zone.

14 So this is all tied together. It's a little

15 premature for us to really say much about what it means for

16 conceptual model until we get at what the differences are in

17 the data sets.

18 So maybe this time next year we can tell you, give

19 you a final answer on that.

20 That's all I have.

21 MR. WYMER: Milt, questions? Okay. I'll start

22 out, then. Obviously, it is extremely important to

23 understand these data, because they do bear on one of the

24 most important parts of the whole repository; namely, how

25 fast is the water moving and by what mechanisms, and you've

1 known about the disparity quite a while.

2 What is it about the analyses that takes so long

3 to cross-check and confirm? It seems to me that could have

4 been done by now.

5 MR. PETERS: Well, the differences really were

6 just exposed in the spring. We just really started to

7 understand that there were some significant differences in

8 the spring timeframe.

9 MR. WYMER: Three months.

10 MR. PETERS: I understand.

11 MR. WYMER: Four months.

12 MR. PETERS: There's been some constraints. There

13 hasn't been as much work done at the laboratories because of

14 other competing priorities associated with AMRs and stuff.

15 I mean, it's project priorities, to some extent, that have

16 caused not as much laboratory work to be done in this area.

17 That may not be what you want to hear, but that's

18 the reality.

19 MR. WYMER: You're right. Okay. Well, that's my

20 question. Milt?

21 MR. LEVENSON: Yes. I've got a couple of

22 questions. The numbers that you have for the ratios, one

23 for the pre-bomb and the other for the bomb pulse, are those

24 average for the entire atmosphere, the 500 and the 1,200?

25 MR. PETERS: Let me be clear. The actual ratio --

1 that wasn't clear on the slide. The actual ratio for bomb
2 pulse water is much higher. That 1,200-ten-to-the-minus-15
3 is what we see when we take a sample of rock in the ESF. We
4 think anything above that is bomb pulse.
5 But the ratio for the actual bomb pulse chloride
6 is two orders of magnitude greater.
7 MR. LEVENSON: So the atmosphere concentration, if
8 you sample the air anyplace, it's going to be two orders of
9 magnitude higher than that.
10 MR. PETERS: For the bomb -- June, help me out
11 here maybe.
12 MS. FABRYKA-MARTIN: The ratio of 500 for
13 background is based on samples from the Yucca Mountain area,
14 actually the Yucca Mountain region. It's based on three
15 types of samples; soil profiles, for one, where once we get
16 below the bomb pulse in the soil profile, then we use those
17 -- the numbers that are clearly below where the pulse is as
18 part of the database.
19 The second source of samples are packrat samples
20 from packrat urine, that's fossilized. We carbon date the
21 sticks that are stuck in the midden and then use the
22 chlorine-36, the ones that clearly aren't recent, to show us
23 what the background has been.
24 And then the third type of sample is ground water
25 itself that doesn't have any tritium or C-14 indicating

1 absence of bomb pulse there, as well.

2 All three sources have been consistent in defining

3 that background.

4 Now, the 1,200 is a statistically derived

5 threshold. So we're saying that once it's above 1,200, then

6 we're confident that it's unambiguous evidence that it's

7 clearly elevated above natural background, and that's based

8 on a database of about 300 results from the tunnel and it's

9 also supported by our packrat midden samples where we never

10 saw any ratios as we went back to as far as 35,000 years.

11 None of those carbon dated samples were ever

12 higher than about a thousand or 1,100 or so

13 times-to-the-minus-15.

14 MR. LEVENSON: But I still don't have an answer to

15 my question as to what the source term is. What is the

16 ratio in the atmosphere from bomb debris?

17 MS. FABRYKA-MARTIN: Why do you care? I mean,

18 because --

19 MR. LEVENSON: Why do I care?

20 MS. FABRYKA-MARTIN: Because once it hits -- as

21 soon as it hits --

22 MR. LEVENSON: Because how do I know how credible

23 your 1,200 is if I don't know the source term?

24 MS. FABRYKA-MARTIN: The thought I had -- well,

25 first of all, it would be hard to collect a sample from the

1 atmosphere that did not have bomb pulse in it.

2 MR. LEVENSON: No, no. I don't want the

3 background from the atmosphere. I want the present

4 concentration of bomb pulse in the world, the source term

5 for this.

6 MS. FABRYKA-MARTIN: Okay. We do have samples of

7 runoff water, would you accept that? Runoff catched from

8 channels from USGS investigators?

9 MR. LEVENSON: If that's the best you can do. Is

10 that what you consider representative of the atmosphere?

11 MS. FABRYKA-MARTIN: No. No.

12 MR. LEVENSON: The source of the bomb --

13 MS. FABRYKA-MARTIN: The reason I say that is the

14 moment that a drop of water reaches the surface, it's

15 already being diluted by what's already there, what's

16 accumulated there over the thousand -- or hundreds of years

17 or tens of years.

18 So I'm not sure what --

19 MR. CAFFEE: Not to disagree with anything June

20 said, but one of the --

21 MR. GARRICK: Identify yourself, please.

22 MR. CAFFEE: My name is Mark Caffee, from Lawrence

23 Livermore National Lab. We can recreate what the bomb pulse

24 input is from looking at ice core data. So there's been

25 extensive studies of chlorine-36 deposition at the Vostock

1 ice core and in Greenland ice core samples.

2 So we can go -- we have gone back, these studies

3 have been done by a number of groups, and reconstruct that

4 profile of the bomb pulse chlorine-36 in the atmosphere.

5 I'm positive that I didn't bring a viewgraph of

6 that with me, but the chlorine-36 to chloride ratios are

7 very, very high and what you see is kind of what you expect,

8 that a few years after the atmospheric testing of nuclear

9 weapons, you had a peak in the chlorine-36 and then it has

10 fallen off since.

11 I don't know if that answers your question, but

12 that's kind of the --

13 MR. LEVENSON: What's the current day, current day

14 ratio?

15 MR. CAFFEE: If you just went out and got

16 precipitation, it would be back to what it was before the

17 bomb pulse, before the bombs were exploded.

18 MR. GARRICK: If you want to comment, you have to

19 do it in a mic.

20 MR. CAFFEE: What June was going to say is someone

21 has looked at precipitation in the environ of Purdue

22 University and for what we believe the pre-bomb chlorine-36

23 to chloride ratio was, it has gotten back to that again.

24 But it's not the case that there have been

25 thousands of measurements of chlorine-36 to chloride ratio

1 in rain waters all across the country or all across Africa
2 or anything. These contours of input are drawn based on not
3 a great deal of data points.
4 MR. LEVENSON: What's the precision and accuracy
5 to one significant figure of these analytical methods for
6 this ratio?
7 MR. CAFFEE: Okay. I'll answer for Livermore. I
8 won't try to answer for anybody else. The measurement
9 itself is much better than five percent, based on counting
10 statistics. By the time we fold in blank corrections, and I
11 can address the Livermore data here, the uncertainties may
12 go a little above five percent, but they're probably still
13 less than ten percent.
14 MR. LEVENSON: Five percent is the precision or
15 the accuracy?
16 MR. CAFFEE: Precision.
17 MR. LEVENSON: What's the accuracy?
18 MR. CAFFEE: I don't know how to answer that
19 question.
20 MR. LEVENSON: That's the most important question
21 here.
22 MR. CAFFEE: Of course it is, but what we're
23 trying to do, I can tell you that other samples, not Yucca
24 Mountain samples, but other samples, for example, in situ
25 chlorine-36 produced in carbonates in Greece and Italy and

1 all across the world have reproducibilities that are
2 comparable to our precision.
3 So for samples where we have a long history of
4 running things and our researchers have sent us duplicates
5 and triplicates, we believe that our accuracy is comparable
6 to the precision.
7 But for me to get up here and tell you that our
8 numbers at Livermore are absolutely accurate and there can
9 be no other circumstances that can change those ratios, I
10 can't answer that -- I can't do that.
11 MR. LEVENSON: Let me ask one other question,
12 which is a completely different type, because I was at the
13 meeting in Pahrump four months ago when this first came up
14 and there was discussion then that the simplest thing to do
15 was to take some aliquots from a processed sample and run it
16 both places and rather quickly eliminate whether the
17 analytical method was relevant or not, and it doesn't sound
18 like that has been done yet. Is that correct?
19 MR. CAFFEE: No, we have not done that. I don't
20 recall -- that was quite a while ago. I don't recall it
21 being mentioned. I don't doubt that it was mentioned. I
22 would, again, in answer to that, say that over a course of
23 six years of running, we have run duplicates of aliquots
24 many, many times, from meteorite samples, lunar samples,
25 rock samples from all over the world, and secondary

1 standards, NIST standards, a whole variety of things and we
2 have comparisons with samples run between ourselves and
3 Zurich, between ourselves and the old lab at Rochester, and
4 I even believe between ourselves and Purdue.
5 MR. LEVENSON: But that's not really the issue.
6 The issue is to try to resolve why the difference and it
7 potentially --
8 MR. CAFFEE: I'm not disagreeing.
9 MR. LEVENSON: You've attempted to get rid of the
10 sampling difference by splitting a sample. I think that's
11 an acceptable method of doing it, and you could fairly
12 quickly resolve whether it's processing or analysis by the
13 two labs running the same sample. I just don't understand
14 why --
15 MR. CAFFEE: This is one of the things that will
16 certainly be done with this standard reference material,
17 because here we have enough sample that we can precipitate
18 enough silver chloride that we can make splits.
19 The chemistry that's done on the core samples is
20 difficult enough that after we have precipitated silver
21 chloride, we generally don't have enough to make splits. We
22 make enough silver chloride for one, perhaps two analyses.
23 So we don't have in our laboratory a supply of
24 silver chloride from the ESF samples. To do that would
25 require processing much more sample than we've got.

1 And let me make one further point. When we got
2 into this, what I assumed was that we would measure these
3 samples and we would see bomb pulse chlorine-36 in all of
4 those samples. That was my assumption.
5 Now, if we had made those measurements and
6 observed those elevated ratios and everything, we wouldn't
7 be here. No one would be asking questions about precision,
8 no one would be asking questions about accuracy, no one
9 would be asking questions about did you shake your samples a
10 certain way and do you shake your samples a different way.
11 We have seen a big difference, though, and I think
12 it's important, but it's going to take time to go through
13 and resolve those.
14 So the initial work was not done anticipating this
15 kind of problem. Had it been done anticipating this kind of
16 problem, we would have had to spend a whole lot more time to
17 do the work.
18 MR. LEVENSON: We're not talking about prior to
19 May, just the concern. I must say -- let me record a
20 personal comment, that whoever sets the priorities so that
21 the paperwork has higher priorities than resolving a problem
22 as important as this really ought to reassess what they're
23 doing.
24 MR. HORNBERGER: I have just a quick follow-up.
25 You were rudely interrupted when you were talking about your

1 lab comparisons and I just wanted to know --

2 MR. CAFFEE: Did I interrupt myself?

3 MR. HORNBERGER: That was it. I just wanted to

4 know if Livermore -- have you done inter-lab comparisons

5 with Purdue?

6 MR. CAFFEE: You know, not in recent years, but I

7 think we have.

8 MS. FABRYKA-MARTIN: One of the first things I did

9 when I became PI on this project back in 1990 was to do an

10 inter-lab comparison with results from Rochester, which was

11 still running then, Livermore, and Purdue. And I think I

12 sent out a total of four blind samples that all four labs

13 had done and they did pretty well.

14 I don't remember the exact numbers, but they were

15 within two sigma, for sure, of one another and I was

16 satisfied.

17 MR. WYMER: How much variation do you find in

18 total chloride content concentration from various samples

19 that you've taken?

20 MR. CAFFEE: For in general or for the validation

21 sample specific?

22 MR. WYMER: I want to know whether there's a

23 factor of two, three or five of chlorine concentration from

24 one spot to another in the repository.

25 MR. PETERS: How much does the chloride

1 concentration vary, say, June, in your samples, from north
2 to south ramp?
3 MR. WYMER: Is one saltier than the other?
4 MS. FABRYKA-MARTIN: Okay. Do you want to
5 rephrase that so you're talking -- whether or not you're
6 talking about pore water or total amount of chloride leached
7 from the sample or a function of --
8 MR. PETERS: I would answer both.
9 MR. WYMER: Yes.
10 MR. PETERS: Answer pore water and then --
11 MS. FABRYKA-MARTIN: Pore water, it's about -- in
12 the pore water, in the south ramp, it's about 80 milligrams
13 per liter, on the average. North ramp, we saw much lower
14 values, I'd say averaging maybe 20 milligrams per liter,
15 and, also, along the cross drift, about 20 milligrams per
16 liter.
17 As far as chloride leached from the rocks, a very
18 general trend that I saw with a lot of scatter was that we
19 generally saw bomb pulse -- the samples that we saw bomb
20 pulse in were the samples that had the lowest quantities of
21 chloride leached from the rock, whereas the ones that had
22 the lowest ratios tend to have higher chloride, and that
23 would be in terms of we did a one-to-one leach, one kilogram
24 of rock to one kilogram of water and saw concentrations
25 anywhere from maybe 0.3 milligrams per liter, which means

1 0.3 milligrams leached per kilogram of rock, on up towards
2 maybe an order of magnitude or more higher.
3 Does that answer the question?
4 MR. WYMER: Sort of. In your analyses, there was
5 no normalization with respect to the amount of total
6 chloride, or was there?
7 MS. FABRYKA-MARTIN: No. We measure the ratio on
8 what gets leached out and it's an important point to realize
9 that we're not trying to maximize amount of chloride leached
10 from the rock.
11 In fact, it's just the opposite. We're trying to
12 minimize how much chloride we leach from the rock, because
13 we don't --
14 MR. WYMER: I understand that. It just seemed to
15 me that if there was four times as much chloride to start
16 with and you had the same amount of chlorine-36, you might
17 change your ratio.
18 MR. PETERS: I think that's what I tried to
19 convey. June, the concentration in the validation samples
20 for chloride, what was yours, and then, Mark, I guess, what
21 was yours?
22 MS. FABRYKA-MARTIN: It was about 0.3 milligrams
23 per liter that was leached from the validation samples.
24 MR. PETERS: I don't mean to put you on the spot.
25 MR. CAFFEE: Sure. But my recollection, without

1 having my raw data here, is that it's .8 to 1.5, maybe even
2 two for a couple -- ppm, so one ppm. We're definitely a
3 little higher than June's.
4 MR. GARRICK: I was just curious. I'm not a
5 chemist, so I can't ask good questions like you've been
6 getting.
7 But this technique of measuring for bomb pulse,
8 that chlorine ratio tracer technique or actual measurement
9 technique has been around for a long time, has it not? And
10 there's bore holes all over the Nevada test site, are there
11 not?
12 So there must be a lot of experience in doing
13 this.
14 MS. FABRYKA-MARTIN: No. What's new here, what's
15 really unique is the fact that we're leaching -- we're
16 trying to measure chlorine-36, where there essentially is
17 not much water, so you're leaching rock.
18 And here, unlike those other types of sample
19 types, you really have to watch out for diluting your sample
20 with salt that's trapped in the fluid inclusions or grain
21 boundaries or wherever it is. That's what is unique.
22 I don't know of anyone else who is doing that.
23 They do it in soils, tons of studies using soils, looking at
24 in situ chloride in different mineral species, ground
25 waters, but unsaturated rock, I can't think of anybody else.

1 MR. GARRICK: So you think that the unsaturated
2 rock and the uniqueness associated with that makes this a
3 pretty much one of a kind sampling operation.
4 What I'm getting at is that with all the
5 experience that you've had at the Nevada test site and the
6 bore holes, you must have -- have you -- you must have had
7 either agreements or disagreements in the past and the
8 necessity for confirmation or reconfirmation.
9 I'm just trying to get at if you've had similar
10 experiences in the past, why can't we attack them the same
11 way.
12 MR. CAFFEE: I'll answer that different, actually.
13 First of all, you mentioned that the technique has been
14 around for a long time, but while it's been around for a
15 while, it's not the case that this is a routine technique,
16 like Argonne-Argonne dating, for example.
17 If you think about how long Argonne-Argonne dating
18 has been around, in the first couple decades, it was
19 probably a pretty painful start, too. So that's the first
20 point I'd like to make. It's still a difficult measurement.
21 We're measuring a million atoms of something. So that's not
22 easy.
23 The second point I guess I would like to make is
24 that I think, to the best of my knowledge, the only person
25 that has leached this kind of rock to get chlorine-36 out

1 for AMS analysis is June.

2 It's not the case that the literature is just

3 totally, totally filled with this kind of thing. There's a

4 lot of data on in situ produced or cosmic ray produced

5 chlorine-36. There's a lot of data on chlorine-36 in ground

6 water. Those are all laboratory techniques that we all know

7 how to do and we can all do that.

8 But you won't go open Geochemic and find a whole

9 lot of articles on this kind of application.

10 MR. GARRICK: I see.

11 MR. CAFFEE: So I find this disparity in results

12 not that surprising, to be honest with you. I mean, I think

13 it's just the normal process of --

14 MR. GARRICK: Is this the kind of thing where a

15 sample could be sent to an independent lab outside the

16 weapons complex, for example, and --

17 MS. FABRYKA-MARTIN: I have sent samples to Purdue

18 to process in the past, with mixed results, because I didn't

19 define the protocol very well. Some samples came in right

20 where I expected them. Others, they crushed them too

21 finely, so they came down a little, not as low as Mark's,

22 but down lower than expected.

23 But I would like to point out that I'm not the

24 only one who applied this technique. What would be a fair

25 statement is to say Yucca Mountain project PIs have been the

1 only ones to apply this technique. But I wasn't the first
2 PI on this and, furthermore, my technicians don't allow me
3 in the lab really, with good reason probably, and there's
4 probably, over the last -- this project has been going on --
5 the chlorine-36 project has probably been going on more than
6 15 years or about 15, let's say, maybe slightly more and
7 it's had probably five different technicians on it over the
8 years that have processed samples and the samples have
9 always been consistent from one technician age to another,
10 and that's under two different PIs.
11 At first, they used to be done at a lab in Tucson,
12 Hydro Geochem, and then it got moved to where I am now.
13 MR. GARRICK: That was the basis of my original
14 question, the process that is employed in the lab to make
15 the measurements, governed by the same more or less
16 prescriptive process.
17 MS. FABRYKA-MARTIN: Yes. That part is true.
18 MR. GARRICK: And was that true for Purdue?
19 MS. FABRYKA-MARTIN: I had them write the
20 procedure that they used and send it to me along with the
21 results when I really should have gotten in on the very
22 beginning and looked over what they had proposed to do.
23 I didn't bring those data with me, but it's still
24 up in the hundreds, the ratio was up in the hundreds, not
25 down in the 100 or less.

1 MR. WYMER: Are you comfortable with the fact that
2 fines might give you a different ratio than stuff not so
3 finely crushed?
4 MS. FABRYKA-MARTIN: Yes, I am.
5 MR. WYMER: Tell me why.
6 MS. FABRYKA-MARTIN: Because the finer it gets,
7 the more likely it is you've broken along grain boundaries
8 or opened food inclusions or made it --
9 MR. WYMER: That changes the ratio?
10 MS. FABRYKA-MARTIN: The chlorine-36 to chloride
11 ratio simply because then it releases that in situ produced
12 chlorine-36 that's made by neutron capture on chloride and
13 include an inclusion source, grain boundary, wherever it
14 resides, as opposed to what's flowing along the micro
15 fractures between the grains.
16 MR. WYMER: I understand.
17 MR. PETERS: Let me follow-up with a question
18 here. Have you guys plotted the chlorine-36 to chloride
19 ratio against -- on the Y axis against on the X axis to
20 total chloride?
21 MS. FABRYKA-MARTIN: We did for the Los Alamos
22 results.
23 MR. PETERS: Do you get just basically a straight
24 line?
25 MR. CAFFEE: Yes, sir. I do.

1 MR. PETERS: Then what you may, in fact, be
2 looking at, these high ratios, could very well be simply how
3 much non-radiogenic chloride you release from the rock and
4 then the question becomes are you, in fact, measuring any
5 bomb pulse anywhere, because if all your ratio fluctuations
6 have to do with how much chloride is there total, which is
7 15 orders of magnitude more stable chloride than there is
8 chlorine-36, very small changes in your stable chloride
9 amount released from the rock could very well be driving
10 this whole ratio.
11 So how do you resolve that problem?
12 MR. CAFFEE: Let me make two comments about that.
13 First of all, you asked me if we had plotted the chlorine-36
14 ratio versus the chloride, and I said there was no definable
15 trend. It was just a straight array. That's plotting
16 chlorine-36 over chloride versus one over chloride. So
17 trying to come up with a mixing diagram. That's the first
18 thing.
19 The second thing is I think the thing you need to
20 bear in mind is that there may well be two issues here. The
21 first issue is that in the Livermore measurements, there's
22 no bomb pulse chlorine-36 in any of our measurements, and
23 the bomb pulse chlorine-36 ratio is substantially higher.
24 It's higher by more than factor of ten than what we -- by a
25 factor of ten, what we're measuring.

1 Then there is also a difference in the validation
2 samples, systematic difference between the Livermore ratios
3 and the Los Alamos ratios. The Los Alamos ratios are a
4 factor of two to five, something like that. That
5 difference, the latter difference that I mentioned could
6 well be some sort of an effect of diluting the signal with
7 chloride.
8 That's possible. We haven't proven that that's
9 the case or proven it's not the case, but I agree with your
10 line of reasoning and that's part of our path forward is to
11 look into that.
12 We don't see any bomb pulse I don't think can be
13 explained by chloride dilution, because you would be having
14 to dilute the chloride by an order -- or the entire chloride
15 inventory by a lot of chloride and we would pick that up.
16 We would know that. We would be measuring 20 to 50 or 100
17 ppm of chloride in the leached sample, and we're not seeing
18 that.
19 We're seeing a ppm to two ppm, June is seeing a
20 couple of ppm. So I think there's two different things that
21 you need to bear in mind. There is the difference -- there
22 is the fact that our results are systematically different
23 and this might have something to do with laboratory
24 protocols.
25 But then there is also the fact that we don't see

1 any chlorine-36 or bomb pulse chlorine-36, and I don't
2 believe that that can be explained by dilution with dead
3 chloride.
4 MR. CAMPBELL: But you're also not seeing modern
5 chlorine-36.
6 MR. CAFFEE: Bomb pulse, modern chlorine-36.
7 MR. CAMPBELL: I mean pre-bomb pulse. If the
8 ratio has been somewhere between 450 and, say, 1150 for the
9 last 50,000 years, maybe the last million years, and you're
10 looking at ratios of 50 to, say, about 150, you're looking
11 at very old chloride.
12 So it's not just that you don't see bomb pulse
13 chlorine-36. What you're seeing is very old chloride
14 relative to any of the samples that Los Alamos has.
15 MR. CAFFEE: That's right. If there were no other
16 data in this world and we only had the Livermore data and I
17 couldn't do any more experiments, I couldn't look and see at
18 the stepped release of chloride and I couldn't investigate
19 these processes, and someone forced me to interpret this, I
20 would have to say that based on the fact that the modern
21 input is about 500 and our ratios are less than 200, that
22 we're seeing decay of chlorine-36.
23 So we would interpret our data as indicating very,
24 very old pore water, older than -- comparable to a half-life
25 of chlorine-36.

1 Now, I think it's way too early to try to
2 interpret that data like that, but if that's all I had,
3 that's the way I would interpret it.
4 MR. PETERS: But as you kind of alluded to, if you
5 look at the Los Alamos data on the validation samples, it's
6 comparable to what you would expect to see for background.
7 If you go back -- right, June? I mean, the
8 chlorine-36 to chloride ratios for the Los Alamos validation
9 samples is in the range of five, six,
10 700-ten-to-the-minus-15, which is very similar to what she
11 -- what you were seeing in background throughout the ESF.
12 Now, granted, they haven't seen anything above
13 1,200 in those Sundance fault cores yet, and I say yet,
14 that's key, but --
15 MS. FABRYKA-MARTIN: I don't think we will.
16 MR. PETERS: Okay. Fair.
17 MS. FABRYKA-MARTIN: There's not that much core
18 left for us to process at Los Alamos. Most of the core has
19 already been spoken for.
20 So we may not have a whole bunch more samples
21 coming from validation bore holes, but the ones we do have,
22 it's true, they're background. I wouldn't call it bomb
23 pulse in what we've had come back.
24 On the other hand, when we did find a bomb pulse,
25 we had a structural geologist pick our location, saying this

1 looks like a likely flow path, sample here.

2 We were very careful to try to sample right along

3 the fractures, so we would maximize the amount of fracture

4 surface in our samples, and that's not the case for the bore

5 holes.

6 MR. HORNBERGER: Can you -- well, you certainly

7 have looked to see whether or not the processing is

8 different at some coarse level. Can you summarize if there

9 are any coarse differences? Are people looking at different

10 size fragments, leaching times, are the leaching times

11 different, anything different sort of at that macroscopic

12 level?

13 MS. FABRYKA-MARTIN: He shook his samples for

14 seven hours and we just let ours stew in the soup pot at

15 room temperature for a minimum of two days and stir it once

16 a day.

17 So it's passive versus an active extraction

18 procedure, and that's what we're both investigating now,

19 what is the effect of that on extracting both total chloride

20 and then, even more importantly, on the chloride to bromide

21 ratio, which is the indicator of how much of it is coming

22 from the rock.

23 MR. PETERS: So have you both looked at the

24 chloride to bromide ratios?

25 MS. FABRYKA-MARTIN: We're trying. The problem is

1 that the leachates are so extremely dilute, that we can both
2 get good numbers for chloride, but when it comes to bromide,
3 it's really dicey.
4 So right now, it looks like what we need to do is
5 to up the scale of the experiments large enough that we can
6 take a large enough volume of leachate out at each time in
7 step to evaporate down and concentrate it.
8 But the problem we have is, at least at Los
9 Alamos, is my chemist is about 100 percent Busted Butte
10 project, which means she only does analyses pretty much as a
11 favor, because there's not really a lot of funding and this
12 is a much lower priority than Busted Butte. And so she's
13 processed -- measured a lot of samples, but it takes a
14 couple months to get the analyses out.
15 MR. CAFFEE: Let me agree with pretty much that in
16 its entirety. One of the things that we do want to do is
17 measure the bromine in these fractions and one of the things
18 that we want to do, and we've started, but we haven't
19 completed the analyses, is leach for two hours, leach for
20 four hours, leach for six hours, eight hours, maybe go back
21 and look at fines, I think that's a good idea, too, do all
22 of these kinds of things.
23 It takes time to do these kinds of things and
24 we're working on it and we don't have the results in any
25 state where we could talk about them today.

1 Regarding the bromide measurements, I think that's
2 really important. It's just a hard measurement. It's a
3 very hard measurement and so we have a new chromatograph and
4 we're trying to make those measurements, but we just have to
5 get to the point where we feel confident that they're right.
6 MR. HORNBERGER: Mark, you mentioned in your
7 presentation that you had a chlorine-36 peer review panel.
8 I guess that's new to me.
9 Can you tell me how many are on it and how many
10 people are from inside the program and how many people from
11 outside?
12 MR. PETERS: It was -- I wouldn't be able to
13 recount the names of the folks. It was four folks. It was
14 the DOE initiated external peer review committee, went
15 through a whole series of these back at that same timeframe,
16 in pre-VA release timeframe, and this was one of those.
17 In fact, they -- one of their big pushes was to go
18 to more of a different sampling approach with a cross drift,
19 and that was actually implemented.
20 So we did different ways of sampling for the
21 features in the cross drift than we did in the ESF as part
22 of their comments, but they did a full-blown peer review and
23 that agreed basically with where we were at with the program
24 at that time, anyway.
25 MR. WYMER: Any other questions? Bill? Well,

1 we're pretty much right on schedule. Thank you very much.
2 It's a very important issue. I hope that it gets resolved
3 shortly.
4 MR. GARRICK: The next presentation is on fluid
5 inclusions.
6 MR. WYMER: Let's get started here. In light of
7 the confusion, I think I would just as soon you would
8 introduce yourselves as you speak.
9 As I understand it, what we're basically trying to
10 decide is whether the Yucca Mountain repository is a shower
11 or a bathtub. Please, proceed. Introduce yourself and your
12 affiliation.
13 MR. DUBLYANSKY: I would say Jacuzzi rather than
14 bathtub.
15 Gentlemen, my name is Yuri Dublyansky. I
16 represent the State of Nevada here and, also, I am an
17 employee of the Russian Academy of Science. I am a senior
18 scientist in the Institute of Mineral Geology, Geophysics
19 and Mineralogy.
20 I am very glad that I have this opportunity to
21 introduce the fluid inclusion issue for you and the reason I
22 am so happy, and I even flew all the way from Siberia
23 yesterday to attend this meeting, the reason is that this
24 issue, which I believe is very important, exceptionally
25 important for the Yucca Mountain safety and performance, has

1 been neglected for quite a few years. That's my personal
2 opinion.
3 Also, I want to say the name of fluid inclusion
4 issue is a little bit misleading. So the real issue is not
5 the fluid inclusion. The real issue is the real origin of
6 secondary minerals at Yucca Mountain.
7 Were they formed by hot water pathway through the
8 mountain or were they formed by rain water percolating down
9 through Yucca Mountain, this is the real issue.
10 And fluid inclusions are just a tool, a very
11 convenient, very robust tool, which allows you to determine
12 temperatures at which the minerals will form.
13 This information, the temperature formation is
14 very important when you try to identify the origin of
15 minerals.
16 Now, I also want to mention that the fluid
17 inclusion method is not something new. It's a very well
18 established technique. It's been around for almost a
19 century. It's widely used in many geological, fields of
20 geology, like oil exploration, mineral exploration, and
21 many, many different applications.
22 As I understand, the ACNW and NRC have not been
23 exposed to this issue for some reason. So I was asked to
24 prepare a short overview of the fluid inclusion work done at
25 Yucca Mountain.

1 First, I want to make it clear, it's not something
2 new. This fluid inclusion issue has been around for almost
3 a decade.
4 In 1992, the panel of the Academy of Science and
5 National Research Council related the hydrothermal review
6 concept which was identified by a DOE scientist as a
7 potential site suitability issue.
8 This review was requested by DOE, because DOE
9 needed to have input to make a decision whether to proceed
10 with characterization or not.
11 So even though this panel, Academy of Science
12 panel discarded this issue, the panel did recommend that
13 fluid inclusion research needs to be done. It was an
14 official Academy of Science report on the issue.
15 As far as I know, the first fluid inclusion data
16 were published in 1993 by Los Alamos researchers Bish and
17 Aronson and they studied several site samples from depths of
18 30 and 130 meters from bore holes and they measured
19 temperatures, fluid inclusion temperatures well in excess of
20 100 degrees Centigrade.
21 While I personally have reason to believe that
22 those data technically are deficient and the temperatures
23 are probably not correct, they're unreasonably high, but I
24 cannot check it, of course.
25 In 1994, the USGS and Los Alamos researchers

1 published a more detailed paper on fluid inclusions from the
2 unsaturated zone at Yucca Mountain, since the tunnel ESF had
3 not been built by that time, they studied samples from drill
4 cores.
5 Well, this paper leaves a little bit mixed
6 impression. On one hand, it does report fluid inclusion
7 suitable for thermometry, suitable for determination of
8 temperatures in core sites from Yucca Mountain, but on the
9 other hand, this paper does not report any numeric data.
10 So they also just made a statement that this core
11 site was formed at a temperature less than 100 degrees,
12 which doesn't really help, because 20 degrees to 100 degrees
13 centigrade is basically the whole range of water from cold
14 water to thermal water which you can expect close to the
15 earth surface, as understood in hydrogeology.
16 In 1995, I had the opportunity to collect my first
17 samples, working for the State of Nevada, from the tunnel,
18 from the first 300 meters of the ESF which were excavated by
19 that time, and I did fluid inclusion, preliminary fluid
20 inclusion research on these samples and reported my finding
21 to the State of Nevada.
22 Later in 1996, part of this work was published in
23 abstracts for two national conferences, Geological Society
24 of America conference and the American fluid inclusion
25 conference.

1 Unfortunately, late in 1995, the State of Nevada
2 -- the funding for the State of Nevada oversight activity
3 was cut and during the next two and a half years, no work
4 was done by the State of Nevada scientists, because just we
5 didn't have money.
6 In 1998, several events occurred. First, the
7 Pan-American conference on fluid inclusion, here in Las
8 Vegas, the USGS researchers Roder and Wellan went on record
9 by stating that core site samples which they studied from
10 ESF do not contain fluid inclusion suitable for thermometry,
11 suitable for determination of the temperature, and,
12 therefore, those core sites were formed by rain water
13 percolating through the mountain.
14 At the same conference, I presented my data, which
15 I obtained from basically samples from the same tunnel, and
16 those data indicated temperature. I did measure it for
17 inclusion temperatures, have found inclusions which are
18 suitable and the temperature was up to 85 degrees
19 Centigrade.
20 So there was quite a disagreement between two
21 groups of researchers.
22 Later, in 1998, the U.S. Nuclear Waste Technical
23 Review Board completed several reports by the State of
24 Nevada scientists, and one of those reports was a report on
25 fluid inclusion.

1 A consultant to NGGRB, Professor Bob Bodnar, from
2 Virginia Tech, evaluated this report and he not always --
3 not only evaluated this report, but he also invited me to
4 his lab and we spent some two days running samples on his
5 equipment, and finally he was convinced that the data which
6 I reported in my '95 report are real and they are not
7 artifacts.
8 So after that, the Nuclear Waste Technical Review
9 Board concluded the fluid inclusions found in mineral
10 deposits at Yucca Mountain do provide direct evidence of the
11 vast percents of fluids at elevated temperatures in the
12 vicinity of the proposed repository. So that was a letter
13 report written by NGGRB.
14 In September-October of 1998, I did more detailed
15 research on fluid inclusions and since, by that time, the
16 state still did not have money for this research, this part
17 of my work was funded by the Institute for Energy and
18 Environmental Research.
19 So the results were released through a press
20 conference in Washington, D.C., and after that, 30 copies of
21 this report were requested by one of the U.S. Congress
22 committees.
23 I also want to mention that before releasing this
24 report, we sent it for external evaluation to three well
25 known, well established experts on fluid inclusion in

1 Europe, specifically in Austria, in France and in the U.K.,
2 and all three experts agreed that the research was done
3 properly and the quality of work is fine and the conclusions
4 are probably fine, too.
5 So although there was some disagreement between
6 the scientists representing DOE and the State of Nevada,
7 have eventually led the DOE to initiate, in April 1999, a
8 verification project on fluid inclusion issue which is
9 currently underway. Dr. Jean Cline, who led this project,
10 will probably tell much more about this project in a few
11 moments.
12 I won't emphasize, I'll probably make some
13 correction, but this project was not initiated in response
14 to the hydrothermal theory proposed by Jerry Szymanski.
15 It's not correct. I quote from one of the memos of this
16 committee.
17 Actually, I started my fluid inclusion research,
18 just viewing this research as a means of very -- testing the
19 hypothesis of Jerry Szymanski about hydrothermal activity.
20 So I wasn't the one who proposed this concept.
21 And when I reported my data and my interpretation,
22 this data, both data and interpretation were questioned and
23 were disputed by the USGS researchers, so that it had a
24 little disagreement in that.
25 So DOE must be given credit for initiating the

1 project which must resolve this controversy and must resolve
2 the situation where two groups of scientists, which study
3 samples collected from the same location, report very
4 conflicting observations and interpretations.
5 So that's my take on this project.
6 Now, USGS researchers and State of Nevada
7 researchers and UNLV people are doing a parallel study
8 basically on the same samples collected, and as far as I
9 understand, the temperatures, elevated temperatures of fluid
10 inclusions, they're getting basically the same temperatures
11 from our samples. But we still do have disagreement on the
12 interpretation of these temperatures and this probably will
13 be the focus of the forthcoming discussion.
14 In closing remarks, I want to say that as you can
15 see, this fluid inclusion issue was started probably in
16 1995, where data was available. Nevertheless, the data have
17 not been used in the DOE major documents, in the viability
18 assessment of 1998 and in the draft environmental assessment
19 statement of 1999.
20 This leads me to suspect that these data will not
21 be used in the site recommendation consideration report,
22 either, which is due later this year.
23 While it's fairly clear that fluid inclusion
24 research is not complete and much more needs to be learned
25 about temperatures, about ages of minerals involved, the

1 distribution, it is my strong opinion that at this point,
2 DOE has no evidence which would justify elimination of this
3 issue from consideration in the TSPA.
4 Thank you very much.
5 MR. WYMER: Thank you very much. Are there any
6 questions on this? That's a very fine introduction to the
7 problem.
8 MR. DUBLYANSKY: Just one moment. I have compiled
9 a list of publications and they are attached to the handouts
10 which I prepared and if you need them, I can try to compile
11 the original publications and send them to you.
12 MR. WYMER: Okay. Thank you. John, do you have
13 any comments or questions? Thank you very much for the fine
14 introduction. I think Jean Cline is next, is that right?
15 Would you give us your affiliation?
16 MS. CLINE: Sure. I'm Jean Cline. I'm an
17 Associate Professor at University of Nevada-Las Vegas.
18 Does anyone have a pointer? Okay. We'll wing it.
19 That's okay. Could we dim the lights a little bit? I've
20 got one dark slide. What I'd like to do -- can you hear me,
21 before I get started? Okay.
22 What I'd like to do this afternoon is to tell you
23 about a project that we are doing. What I would like to do
24 this afternoon is to tell you where we are in this project
25 that we are now conducting to constrain the movement of

1 fluid with elevated temperatures through the Yucca Mountain
2 proposed site.
3 When I put this proposal together, there were four
4 questions that I posed and the project is constructed or
5 designed to answer the following four questions.
6 First of all, do fluid inclusion assemblages
7 record the passage of fluids with elevated temperatures into
8 the Yucca Mountain site. Secondly, if the inclusions are
9 present, what fluid temperatures do these inclusions
10 indicate.
11 Third, if present, when did these fluid incursions
12 occur, and then, finally, how widespread throughout the
13 proposed site were these fluid incursions.
14 The scientific plan that we put together to answer
15 these questions involves four related studies and I'm going
16 to quickly tell you what they are and the methods we are
17 using in these four studies and then I'm going to go through
18 each of these four a little bit more slowly and tell you
19 what the results are and where we're at now.
20 First of all, sampling. The first thing that we
21 did was collect 155 samples from throughout the ESF and the
22 ECRB. If you're looking for a handout, there isn't any. I
23 didn't know there was supposed to be one. I apologize.
24 Paragenesis study next. This is a critical part
25 of this study. The idea was to put together a growth

1 history of each of the samples that we collected and the
2 idea was that if we could understand how each sample formed,
3 we could then compare site to site and put together an
4 overall history for the growth of minerals, secondary
5 minerals throughout the repository site.
6 The two main tools that we used to do this were
7 petrography, mostly using the microscope, and then,
8 secondly, chemical analyses using the electron microprobe.
9 Additional tools that we are using include
10 cathodolominuescence; also, oxygen and carbon isotopes, and
11 we will probably also do some laser ICPMS analyses to refine
12 the chemistry a bit.
13 Third, the fluid inclusion study. Again, the
14 first critical part was to place the fluid inclusions
15 observed in each of the samples in the appropriate
16 paragenetic contacts or growth history of each of the
17 samples. We also looked at the fluid inclusion petrography
18 and then we did heating and freezing studies. The heating
19 studies will tell us about the temperature of the fluids
20 that were trapped. The freezing studies will tell us about
21 the composition of the fluids.
22 The final study is dating. We'll be doing uranium
23 lead, we're in the process now of doing uranium lead and
24 uranium series dating, to put some absolute times on these
25 fluid incursions, and, again, the really critical thing is

1 to place the samples that we are dating in the appropriate
2 paragenetic context with respect to the sample mineralogy
3 and growth history and also the fluid inclusions.
4 I want to tell you a little bit about the
5 sampling, first of all. Again, 155 samples from throughout
6 the ESF and ECRB. The goals were twofold on sampling; first
7 of all, to collect samples of all of the different types of
8 secondary minerals that were present and then to get a good
9 spatial distribution.
10 We tried to collect samples every 50 or 75 meters.
11 In some places, the gaps are a little bit larger. That's
12 because there's no secondary mineralization there.
13 Moving on, I want to tell you about the
14 paragenesis study. This is a view of one of our thin
15 sections. It's about an inch and a half across length-wise
16 here and what we're looking at is a very thin section of the
17 rock as we look at it under the microscope.
18 At the base, what we see in black is some tuff and this
19 sample grew essentially layer by layer upward or outward
20 from the tuff. The mineralogy is mostly calcite and
21 silicate minerals. The blue is epoxy. We needed to use
22 epoxy to stabilize most of the samples.
23 So where you see blue within the sample, that
24 reflects zones of porosity and permeability, and there's a
25 lot of it.

1 What we see in this sample is tuff, which is
2 overgrown by some of the early blockier calcite. There are
3 some discontinuous layers of silicate minerals, quartz,
4 opal, additional tuff pieces that fell in and were
5 encapsulated, bladed calcite that overgrows the earlier
6 blocky calcite and silicates, and is then overgrown by outer
7 sparry calcite, which also contains some layers of opal.
8 This is one of the more complex samples from this
9 site.
10 Another section, just to show you there is some
11 variability. Here we see, again, at the base, some tuff
12 layers, but in this sample, all we see is bladed calcite.
13 So this particular sample site did not see all of the events
14 that produced all of the different minerals at some of the
15 other sample sites.
16 A third sample, again, at the base, some of the
17 blockier, more malsave calcite, a discontinuous layer of
18 quartz overgrown by bladed calcite, which is overgrown in
19 places by, again, the sparry, more equant calcite and opal.
20 Here is some selective dissolution of some of the
21 bladed calcite.
22 What I'm trying to show you here is that the
23 samples are in detail very heterogeneous, but that when we
24 look from sample site to sample site, we see repetition of
25 patterns and the goal here, again, is to put together a

1 growth history for each of these samples and then to link
2 these samples to compare them from site to site so that we
3 know how the secondary mineralization formed throughout the
4 repository.
5 The second tool that we used, I said,
6 significantly was the electron microprobe. What I want to
7 show you next is a probe map of this area right here.
8 On the left, we have a back scatter electron
9 image. It reflects atomic number or atomic weight and you
10 can see there is mostly one color of gray, so we have one
11 mineral here, it's all calcite.
12 The black is micro porosity or permeability and
13 what the permeability or porosity outlines is some our
14 bladed calcite. So we have bladed calcite overgrown by
15 blocky sparry calcite and on the right we have a magnesium
16 map. The bladed calcite is black, indicating very low or no
17 magnesium. However, it is overgrown by sparry calcite,
18 which shows very fine detailed oscillatory zoning of
19 magnesium, interspersed bands of magnesium, varying
20 magnesium bearing calcite.
21 It turns out that this magnesium bearing calcite
22 is one of the more important discoveries that we have made
23 in terms of helping us put together these growth histories
24 for these samples.
25 This magnesium bearing calcite is present in more

1 than 70 percent of the samples across the repository site.
2 It is always the outer-most and youngest calcite.
3 So it's critically important in helping us link
4 the mineralogy from site to site.
5 I will come back to this calcite, because I also
6 is critically important in understanding the age of the
7 fluid inclusions.
8 Cathodolominescence is another tool we used. This
9 figure here is about two millimeters from top to bottom. It
10 just shows you some detailed oscillatory zoning of calcite
11 that luminesces. There are bands that luminesce
12 interspersed with bands that do not luminesce. Luminescence
13 is probably caused by small amounts of manganese and the
14 absence of iron.
15 The important thing is that we look for the
16 location or the presence of this in individual samples and
17 then its presence allows us to link, again, samples from
18 different sites, one to another, and, again, put together
19 the big picture for the repository site.
20 This picture is important in helping us place
21 contextually the fluid inclusions.
22 Summarizing the paragenesis, we have 155 samples
23 that are heterogeneous, yet they show consistent textural
24 and mineralogical patterns.
25 Importantly, the outer mineral zones, which

1 reflect the youngest geologic events, are especially
2 consistent; in particular, the bladed calcite and then the
3 overgrown sparry magnesium enriched calcite.
4 These patterns allow samples from different sites
5 to be related to one another.
6 What are fluid inclusions? A little bit of
7 background, for people that aren't familiar with these.
8 Most minerals precipitate from some sort of fluid
9 and as they precipitate, there are commonly defects that
10 occur in the atomic structure of these minerals and these
11 defects may result in the formation of small holes or
12 cavities in the minerals.
13 As the minerals precipitate, they are bathed in
14 this fluid. So this fluid will fill these cavities or holes
15 and the mineral may overgrow these holes and seal off these
16 small packages of fluid, thus creating fluid inclusions.
17 They are important because they are samples of
18 some ancient geologic fluid.
19 Okay. Now, if these fluid inclusions or these
20 systems are forming at elevated temperatures, then as the
21 whole system cools down, the fluid is going to contract.
22 However, the cavity does not change in size.
23 So if the fluid contracts enough, eventually a
24 vapor bubble is nucleated and this vapor bubble is
25 essentially a vacuum.

1 Now, what we can do to examine these inclusions is
2 to reverse this process, to try to get at the temperature of
3 the fluids that were trapped.
4 What we do is we heat these inclusions up, we
5 monitor their temperature. As they heat up, the vapor
6 bubble, if present, gets smaller and smaller. The
7 temperature at which it disappears is the temperature at
8 which the inclusions homogenize, and that temperature
9 approximates the temperature of the fluids that were
10 trapped.
11 In lower temperature systems, the cooling may not
12 be sufficient enough to make the fluid contract enough to
13 generate a vapor bubble. So lower temperature systems may
14 contain liquid only inclusions.
15 These are the two features that we'll be looking
16 at.
17 Here are some inclusions from Yucca Mountain.
18 What we see here, the dark line is the wall of the
19 inclusion. This is calcite, the mineral calcite. Here is
20 the wall of the inclusion. The majority of it is filled
21 with liquid and there's a small vapor bubble.
22 Here is another inclusion, again, mostly filled
23 with liquid and a small vapor bubble.
24 This is what they typically look like, fairly
25 small vapor bubbles. However, these two phase inclusions,

1 which really, again, reflect the trapping of higher
2 temperature fluids are far outnumbered by liquid only
3 inclusions, which are also shown on this slide.
4 It's hard for me to see them at this angle. These
5 would reflect the trapping of lower temperature fluids.
6 This is a typical data set. We have completed collecting
7 data from all of our samples. Approximately half of the 155
8 samples that we collected contained assemblages of two-phase
9 fluid inclusions.
10 What we see here are three different assemblages
11 located in different places in a sample. However, almost
12 all of the inclusions homogenized over a four degree range
13 from about 49 to 53 degrees C.
14 This is extremely tight data. It's probably the
15 best I've ever seen and it's quite representative of what
16 we've been able to collect at Yucca Mountain.
17 By far, the majority of the two phase fluid
18 inclusions at Yucca Mountain homogenize between 45 and 60
19 degrees C. There are a couple sample sites in the north
20 ramp where we obtained higher temperatures. Our
21 temperatures are as high as 75 degrees.
22 Others, Yuri Dublyansky and some of the USGS folks
23 have obtained temperatures as high as 85 degrees, but most
24 of our data are between 45 and 60 degrees.
25 Where in the samples are these inclusions? Here,

1 again, we see a typical crust with earlier calcite
2 overgrowing the tuff and in this case, the earlier calcite
3 is overgrown only by the magnesium enriched sparry calcite.
4 So this sample site really saw two calcite forming events.
5 This gray line here sort of is the dividing marker
6 between these two types of calcite. The dark squares here
7 show the location of the two phase fluid inclusions, again,
8 that reflect the higher temperature fluids.
9 Outboard of this line, the only inclusions which
10 we observed in this magnesium enriched calcite were one
11 phase liquid only inclusions reflecting passage of lower
12 temperature fluids.
13 This pattern is consistent throughout the ESF and
14 the ECRB. Two phase fluid inclusions are trapped in early
15 blocky or massive calcite and at the very base are in the
16 cores of the earliest bladed calcite.
17 One phase fluid inclusions are trapped in outer
18 bladed calcite and outer magnesium enriched calcite.
19 This slide really summarizes those facts. Again,
20 two phase FIAs, higher temperature fluids are recorded in
21 the earlier calcite, two phase FIAs are not recorded in the
22 outer or younger bladed calcite or magnesium bearing
23 calcite.
24 The two phase FIAs are very consistently either
25 present or absent in different mineralogical zones and these

1 patters allow the relative timing of the elevated fluid
2 temperatures to be constrained.
3 Now, what we really want to do is to absolutely
4 constrain the timing of these elevated fluids, and this is
5 where we're at right now. Here we're looking at the same
6 sample again. The two phase FIAs located in this area here
7 and at the boundary or sort of outboard of this zone of two
8 phase FIAs, there is, fortunately for us, inner-grown,
9 intermittent or discontinuous bands of opal, which contains
10 enough uranium for uranium lead dating.
11 So what we are now in the process of doing is
12 dating some of these opal samples to constrain the timing of
13 this event.
14 Within the magnesium enriched bad, there is a
15 second continuous layer of opal and by dating that, we can
16 determine the timing of the changeover from precipitation of
17 the underlying calcite and the overlaying calcite, and then
18 there is an outermost opal, shown here in yellow, which was
19 deposited synchronous with this outer band of magnesium
20 enriched opal.
21 So right now we're in the process of dating these
22 opal bands. Again, the samples need to be carefully
23 constrained paragenetically in the context of the sample
24 mineralogy.
25 To summarize, our goals for dating are to

1 constrain the age of the latest magnesium enriched calcite,
2 which is free of two phase FIAs. In other words, which did
3 not see the passage of elevated temperature fluids, to
4 constrain the age of the earlier calcite that does contain
5 the two phase FIAs, in other words, which saw the passage of
6 fluids with elevated temperatures, and to determine the most
7 recent timing of fluid passage with elevated temperatures.
8 Concerning where we are with respect to project
9 completion, we are on target for completion and distribution
10 of reports at the end, about the end of March. We are
11 currently finalizing the petrography and the paragenesis.
12 We have completed the fluid inclusion analyses. We are in
13 the process of doing the dating on some of the other
14 analyses and we anticipate that they will be completed by
15 the end of the year.
16 We anticipate reporting significant results,
17 including data, at the Geological Society of America meeting
18 in mid-November.
19 The final comment that I would like to make is
20 that in undertaking, as we have been conducting this study,
21 we have been meeting regularly with scientists from the USGS
22 and the State of Nevada to discuss our procedures, our data,
23 what we're doing, how we're doing it.
24 We have also been meeting with a larger group that
25 includes people from the NRC, Department of Energy, Nye

1 County, the Nuclear Waste Technical Review Board and keeping
2 them apprised of where we are at and what our results are
3 and the goal here is really to inform anyone who is
4 interested what we've done, how we've done it, with the hope
5 that when we are through this project, there will be a broad
6 understanding of what we've done and consensus on the data,
7 if not on all the conclusions.
8 Thank you. I would be happy to answer any
9 questions.
10 MR. WYMER: Thank you very much. The former
11 director of the Oak Ridge National Laboratory, Ivan
12 Weinberg, used to say there was big science and small
13 science. This is certainly small science here.
14 MS. CLINE: Yes.
15 MR. WYMER: Any questions, John?
16 MR. GARRICK: No.
17 MR. WYMER: Do you have a comment over there?
18 Yes, please.
19 MR. DUBLYANSKY: Jean, by saying -- well, by kind
20 of making -- elevated temperature and non-related
21 temperature, ambient temperature, can you put a numeric
22 number on that?
23 MS. CLINE: No. It would be desirable to do so,
24 but we can't. We have homogenization temperatures as low as
25 35 degrees C. So we can have two phase fluid inclusions

1 that were trapped as low as 35 degrees C.

2 The one phase fluid inclusions, there is nothing

3 that we can do to get at the temperature of trapping.

4 People have hypothesized a range of temperatures. I've

5 heard below 90 degrees, I've heard below 50 degrees, I've

6 heard below 75 degrees.

7 It's not -- I don't know how to test that. So

8 it's hard to say. There are -- I guess I'll leave it go at

9 that.

10 In general, I will review the process here. The

11 idea, again, is that as the system cools down, the fluid

12 shrinks, and if it shrinks sufficiently, it generates a

13 vapor bubble.

14 So those fluids that cool down a lot will generate

15 a big vapor bubble. Those fluids that cool down a little

16 bit or a lesser amount will generate a smaller vapor bubble.

17 Those fluids that cool down and shrink minimally will not

18 generate a vapor bubble.

19 But putting a number at those brackets, you can't do it,

20 because in nature, it's going to vary from location to

21 location, fluid composition to fluid composition and so on.

22 I will leave it at that.

23 MR. DUBLYANSKY: I just wanted to comment on that,

24 because from your presentation, seemed to be kind of very

25 clear. We have two phase fluid inclusions, elevated

1 temperature, we have one phase fluid inclusion, it's low
2 temperature.
3 It's not correct, because if you have two phase
4 fluid inclusion, you have an advantage, you can measure the
5 temperature. If you have one phase inclusion, you cannot
6 actually tell the temperature. It may be 30 degrees
7 Centigrade, it may be 50, it might be 60, but just by some
8 reason, this shrinkage bubble did not form.
9 So you should not probably put an equal sign
10 between one phase fluid inclusion and low temperature fluid.
11 MS. CLINE: That I would argue with. I think we
12 can't put a number on it, but in general, we can say that
13 the lower temperature inclusions are those that don't
14 generate a vapor bubble and the higher temperature
15 inclusions do generate vapor bubbles, and we see very, very
16 clear patterns.
17 We see certain mineralogical bands which contain
18 two phase and one phase inclusions and then we see other
19 mineralogical bands that very consistently contain only one
20 phase inclusions, and I'm real comfortable saying that there
21 is a temperature differential that's reflected by the
22 presence of those, but I can't put a number on it.
23 MR. DUBLYANSKY: That means there could be this
24 difference, but it does not necessarily mean that the
25 temperature was ambient.

1 MS. CLINE: Absolutely.

2 MR. DUBLYANSKY: That was the clarification that I
3 wanted to make.

4 MR. WYMER: Is it clear that the all the gas in
5 the bubbles is water vapor?

6 MS. CLINE: Good question. It depends on your
7 hypothesis, on what was trapped. If you believe it was
8 meteoric water, then it probably is a vacuum or just air or
9 a vacuum essentially by the contraction of meteoric water.

10 IF you believe that the fluids came from somewhere
11 else, the source in which those fluids might be transporting
12 dissolve gases of some sort, and in other systems, it's most
13 definitely been shown that that can happen, then that vapor
14 bubble could be something else. It could be carbon dioxide,
15 it could be a mixture of carbon dioxide and other gases.

16 There are some tests that can be done. They're
17 difficult to do and the tests that have been done to try to
18 distinguish that have not definitively shown things one way
19 or another.

20 MR. WYMER: What is the biggest ratio of gas to
21 liquid that you've seen?

22 MS. CLINE: We usually -- the call that we've made
23 is ten percent, ten volume percent or less gas, 90 volume
24 percent or more liquid.

25 MR. WYMER: That's the upper limit.

1 MS. CLINE: Yes.

2 MR. WYMER: That's a lot of contraction.

3 MS. CLINE: I should back up. What I talked about
4 are two types of inclusions, the two phase liquid-vapor
5 inclusions, the one phase liquid only inclusions. There are
6 also some vapor only inclusions that are not well
7 understood. There are not very many of them, but they are
8 present.

9 Then there are also some other liquid-plus-vapor
10 inclusions that have larger vapor bubbles, but these
11 inclusions tend not to have consistent liquid-vapor ratios
12 and that makes you suspicious that they formed under some
13 other circumstance than the ambient conditions at the time.

14 So we throw those out because they are
15 inconsistent. They probably formed as a result of leakage
16 or perhaps what we call necking down when the inclusions
17 were formed.

18 We have textures we can use to sort those out.

19 MR. WYMER: Can you say what the age of the most
20 recently formed bubbles is?

21 MS. CLINE: No. That's the data we're waiting on
22 right now. We have a number of samples that have been
23 submitted to a lab in Ontario. To date, the opal, they've
24 been there for a long time. We thought we'd have more
25 numbers by now. We hope to have them at any time and we

1 hope to be reporting those at GSA. That's a big question.
2 MR. WYMER: Yes.
3 MR. DUBLYANSKY: Can I just add a little bit? To
4 your previous question about gas inclusions. Yucca Mountain
5 does contain all gas inclusions. It basically does not
6 contain visible water. And I tried to study this inclusion
7 by using random spectrometry, but all I got is a huge --
8 which indicates luminescence, which is normally interpreted
9 as the presence of aromatic hydrocarbons there.
10 Enough indication that that's probably the case,
11 but this luminescence decay with time, the hydrocarbons
12 decompose.
13 But still I was not able to identify any
14 particular gases. It's a very interesting subject and I
15 have never seen such inclusion in any other environments.
16 It's very unique, I would say.
17 MS. CLINE: One thing that I could add. The
18 freezing point depression gives us some information on the
19 composition of the fluids and that freezing point depression
20 is very small. So it indicates that there's very minimal
21 salts or minimal gases dissolved in the fluid. Pretty close
22 to pure water.
23 MR. DUBLYANSKY: Can we put a number on that?
24 MS. CLINE: The freezing point depressions were
25 about half -- I don't know, Nick, can you help me out? Do

1 you remember what either the freezing -- minus .6 was the
2 freezing point depression. So about a weight percent NICL
3 equivalent.
4 MR. DUBLYANSKY: So it's not quite -- one weight
5 percent of NICL is not quite fresh water.
6 MS. CLINE: It's not pure water, but it's close to
7 pure water.
8 MR. DUBLYANSKY: It's brackish, I would say, in
9 terms of hydrogeology.
10 MR. GARRICK: Do you have an opinion about the
11 results you might get in terms of whether or not there's a
12 real safety issue associated with the repository?
13 What kind of results would give you some concern
14 about the safety of the repository?
15 MS. CLINE: I guess I'm hesitant to answer that.
16 What we see now -- I think everybody agrees who has been
17 working on this that the fluid temperatures are somewhere in
18 the neighborhood of 50 degrees C and in one area they may
19 get as high as 75 or 80 or maybe even 85 degrees C.
20 What does that mean in terms of engineering the
21 repository site? I don't know that.
22 MR. GARRICK: That's a question we have to answer.
23 We have to answer the so what question and you haven't
24 answered that.
25 MS. CLINE: I think part of the answer -- well,

1 part of what we're doing will help you answer that question,
2 it's going to be the timing of those 50 degree plus fluids.
3 We're waiting for these dates on these opals. They're going
4 to tell us if that happened in the last half a million
5 years, million years, five million years ago, nine million
6 years ago. I think that's going to be a big part of the
7 answer.
8 MR. GARRICK: What if it's ten million years ago?
9 MS. CLINE: Well, it's a blink of an eye in
10 geologic time.
11 MR. GARRICK: I'm talking about the safety of the
12 repository. What's it mean?
13 MS. CLINE: We would have to take the data that we
14 get from this study and then put together our hypothesis of
15 where that water came from and until I get the dates, we
16 can't do that.
17 If the hot water happened ten million years ago,
18 there were hot volcanic rocks there ten million years ago.
19 That's the obvious answer. If the hot water was there a
20 million years ago, something else was responsible for hot
21 water being there, and I don't know what that is at this
22 moment.
23 I'm willing to wait for the dates before I try to
24 answer that.
25 MR. GARRICK: Thank you.

1 MR. WYMER: Any other questions or comments?
2 MR. GARRICK: Do we have another presentation?
3 MR. WYMER: Who is next? Would you introduce
4 yourself and your affiliation, please? Thank you, Jean.
5 MR. GARRICK: Thank you.
6 MR. PETERMAN: My name is Zell Peterman and I'm
7 with the USGS. I'm currently the Team Chief for the Yucca
8 Mountain Project Branch Environmental Science Team. We
9 certainly agree with Yuri's earlier statement that this is
10 not a fluid inclusion issue, it's a calcite multiple
11 fracture filling issue, but I have to add to that that fluid
12 inclusions aren't the only evidence that's going to resolve
13 this issue.
14 In fact, we think it's already resolved.
15 What I would like to do is step back in time a bit
16 and if somebody will show me how to work this projector, the
17 computer thing.
18 The USGS has been studying these fracture
19 minerals, first, in drill core and then later in ESF since
20 about 1989 and prior to that, there were some early studies
21 in the mid '80s of calcite fracture fillings in drill core.
22 Listed at the bottom here are the people actually
23 doing the work. Joel Whelan is the person principally in
24 charge of our fluid inclusion work and the stable isotope
25 work. Landon Namark and Jim Pacies are doing the isotopic

1 dating and Bryan Marshall and I guess to some extent myself
2 are worried more with the isotopic heavy isotope signatures
3 in these materials.
4 So let's have a quick look here. Can I move
5 around here? Is that coming through? What do these things
6 look like? The fracture minerals occur in fractures and
7 lithofizal cavities. Calcite and opal are the main
8 minerals, although there are other minerals present, clay
9 minerals, zeolites, manganese oxides and probably some
10 others.
11 The coatings, as Jean said, range in thickness
12 from several millimeters to several centimeters. These are
13 just two examples. The one on the left is an example of a
14 fracture surface and there is a scale there for reference.
15 The small divisions are one millimeter.
16 The one on the right is the floor of a lithofizal
17 cavity, lithofizal cavities are gas bubbles that form at the
18 top of the ash flow sheets as the ash flow degasses, and
19 they're commonly lined with high temperature minerals all
20 the way around.
21 Typically, silica polymorphs and alkali feldspar
22 are the predominant minerals. There are trace minerals of
23 ohemitites, some garnet has been found, things like that,
24 but they encrust the whole inside of the lithofizal
25 cavities.

1 In contrast, the low temperature minerals, calcite
2 and opal, are typically on the bottoms of these cavities.
3 Now, the green coloration is opal, which is
4 fluorescing under ultraviolet light and it's fluorescing
5 because it's a rather large uranium content, up to 500 ppm
6 uranium, typically around 100 to 300 ppm uranium, and this
7 is the key to the dating work.
8 This is what we can date. We can't date the
9 calcite directly because of it's very low uranium content.
10 Why study these fracture minerals? AS far as
11 we're concerned, the USGS is concerned, they are the
12 physical records of long-term infiltration through the UZ.
13 This is -- I think what Jerry Szymanski refers to as the
14 USGS rain water hypothesis, and actually I kind of like
15 that.
16 Our conclusion after looking at all sorts of data
17 is that these were formed by downward percolating water.
18 We can date these things, as I mentioned, by
19 uranium series, uranium lead and carbon-14, and provide a
20 history of deposition and, therefore, a history of the
21 fluids involved in depositing these materials.
22 The calcite especially also contains an isotopic
23 record of the source fluids and we look at oxygen, carbon,
24 strontium and U-234-238 ratios and they contain fluid
25 inclusions that may yield information on the thermal history

1 of the rock mass.
2 From 1990 to 1995, the only thing we had to look at were
3 core samples and this is an exceptional sample here. And we
4 tried to do some dating, some mineralogy, some isotopes. Our
5 eyes were really opened when the ESF was constructed and we
6 found deposits like this, which never would have survived a
7 coring process.
8 So we were really misled by what was available in
9 only the cores. And the ESF materials are far superb. We
10 can collect good samples and, again, this green coloration
11 is fluorescing opal on the tops of these very delicate
12 calcite crystals that are growing up from the base of a
13 lithofizal cavity.
14 So this is the history, that was the core. Core
15 studies were up to 1995 and in '95 we ramped up our efforts
16 because of ESF, did a lot of isotopes, mineralogy, fluid
17 inclusions.
18 Our early focus was on the history of the
19 outer-most surfaces, because we were testing a model at that
20 time, in 1995, that, in post-glacial times, the PTN was
21 acting as a unit that moved the flow of water laterally
22 rather than allowing it to come down.
23 So we were tasked with what is the under stage on
24 the outer-most surfaces that you can find, the idea being
25 that we probably wouldn't find anything less than 10,000

1 years.

2 A more recent focus has been the long-term

3 deposition on the thermal history of the UZ, the

4 compositional evolution of fracture water, and turning our

5 age information and abundance information into some estimate

6 of seepage flux.

7 So what do these things look like in the ESF? And

8 you will see some of these tomorrow. There are primarily

9 two major occurrences. There are other minor occurrences,

10 as cementation in fracture zones, things like that. The

11 depiction on the left shows a fracture that opens up, and

12 you will see a lot of these in ESF and you will see that the

13 deposits are typically on the foot wall side of these

14 moderately to steeply dipping fractures.

15 The one on the right is a depiction of a

16 lithofizal cavity and there you will see that typically the

17 deposits are on the bottom.

18 Our interpretation here, and this is not an interpretation

19 that's agreed to universally, is that this indicates some

20 sort of film flow moving down these fractures and it's

21 moving under the force of gravity. So it's staying on the

22 low sides of the opening.

23 In contrast with what we see in the UZ are what

24 you will see in the ESF in the calcite below the water

25 table, and, again, we're looking at drill core. The calcite

1 coats all the surfaces of fractures and commonly fills the
2 fractures.
3 As I say, we interpret the occurrences as
4 indicating downward flow along fracture foot walls and
5 cavity floors. We view this as pretty strong evidence that
6 those cavities have not been repeatedly hydrologically
7 saturated.
8 Jean made these same observations. Calcite and
9 opal are intimately associated in micro stratographic
10 relationships. In other words, you can develop the micro
11 stratigraphy starting with the base, lying on the tuff,
12 going to the outer surfaces, and, in many case, you can
13 convince yourself that this is an age progression.
14 We have data from WT-24 which says that the
15 average calcite abundance in the rock mass and the crystal
16 pore member of the Topapah Spring tuff is .24 weight
17 percent, and I will show you that data in just a minute.
18 Calcite dominates, as you saw in Jean's slide,
19 probably less than ten percent, ten percent or less opal and
20 other minerals. The deposits aren't homogeneously
21 distributed in ESF and the greatest abundance that we've
22 measured and another way we've measured is conduct line
23 surveys and actually stretch a line, a 30 meter line every
24 100 meters and measure the thickness of the calcite deposits
25 in fractures and in lithofizal cavities.

1 And this is an example of the data from WT-24,
2 which we thought was another way to get an idea, and WT-24
3 was drilled by the LM-300. So there was a lot of cuttings,
4 a lot of ream cuttings. If you've seen the holes drilled by
5 that, and these cuttings were captured for us, integrated
6 five foot samples and from those five foot samples, we
7 ground them up, prepared a sub-sample and chemically
8 analyzed the samples for C02, and then we assumed that all
9 the C02 as in calcite and that's the way we get the .24
10 weight percent.
11 And that's the mean and, to me, this is analogous
12 to, say, determining the grade of an ore body. So in this
13 case, the arithmetic mean is the appropriate measure, even
14 though the distribution of values is highly skewed and looks
15 almost maybe fractal in nature.
16 There are many, many openings in the ESF that
17 don't have secondary minerals, and this is just an example
18 of one. This is a photo moziac of the tunnel wall over ten
19 or so meters, 20 meters maybe, and the red coloration
20 depicts cavities that have secondary minerals and the white
21 that don't have secondary minerals.
22 So, again, if these were the result of upwelling
23 water, I think we have to ask the question why aren't all
24 the possible depositional sites occupied by calcite.
25 In terms of the isotopic evidence that favors

1 descending water, we have carbon isotopes and the youngest
2 calcites overlap those of the surficial calcrete, and that's
3 the ultimate source of the calcium.
4 If you've been out to Yucca Mountain or anywhere
5 in the desert southwest of the U.S., you will see thick
6 deposits of calcrete that are ubiquitous. And rain water
7 comes down and periodically dissolves this and carries it
8 down fractures.
9 You can see this virtually anywhere you go. The
10 oxygen isotopes in the youngest calcites are consistent with
11 meteoric water heated as it moves down the geo thermal
12 gradient.
13 The strontium ratios in the youngest calcite
14 overlap the values with calcrete, which you'll see in a
15 minute.
16 Work at Los Alamos has shown that the UZ calcite
17 has pronounced negative cerium anomalies. This is not
18 observed in the saturated zone calcite and cerium anomalies
19 are small or nonexistent in ground water.
20 The 234-238 ratios are identical to calcrete, values in
21 calcrete and runoff, and are much smaller than values
22 observed in the tertiary volcanics or ground water.
23 And the conclusion is obvious.
24 MR. HORNBERGER: Can you give me just a quick
25 tutorial on the cerium anomaly?

1 MR. PETERMAN: This is Los Alamos' work and I
2 think it has to do with the oxidation state, the multiple
3 oxidation states and the solubility. This is just an
4 example of the oxygen and carbon isotope analyses that Joe
5 Whelan has conducted. I should have put the number up
6 there. There's a lot of measurements and Joe has also
7 placed the deposits or determined the paragenetic sequence
8 for the deposits, and, again, these are relative things, but
9 he can classify things as early, intermediate and late, and
10 in general, putting the isotopes in that context forms three
11 discreet groups, but with a lot of scatter.
12 But if you get enough analyses, you know that
13 there are clearly three discreet groups there. There is an
14 early calcite that occurs below the cal layer, I think that
15 Jean referred to, and it has these low delta 018 values,
16 which Joe interprets as having formed from water with
17 elevated temperatures, and he's taken water of minus 12.5
18 and then just using the fractionation factor, he would guess
19 that those could have formed from water between 50 and 80
20 degrees centigrade.
21 Here is strontium data on calcite from drill core
22 and at the top there is a histogram. Unfortunately, there
23 is not an indication of the number of samples, but the
24 shortest box there would be one analysis and these are --
25 this is strontium-87-86 values shown as delta 87, which is

1 just the deviation of the 87-86 from that value for modern
2 sea water.
3 So the calcretes have a skewed distribution, but
4 they peak around between delta value of between four and
5 five, and you can see the shallow calcites pretty mimic that
6 distribution and then as you go deeper into the UZ, the
7 numbers go down and then in the SZ, the numbers are quite
8 different, the strontium numbers are quite different than
9 the strontium values in the UZ.
10 We have data from core water salts, from, I
11 believe, SD-6, and we see a very systematic change with
12 depth and what we see is the beginning of a certain amount
13 of water-rock interaction right around the PTN and then
14 continuing down.
15 So we've got a combination of source, plus
16 water-rock interaction here.
17 Geo chronology. We've done carbon-14, uranium
18 series, uranium lead dating, and as I said, our first
19 emphasis was on the outer-most mineral surfaces and these
20 three boxes on the left are nested here or correlated. You
21 can see they each represent different spans of time.
22 We get carbon-14 ages as young as 16,000 years.
23 We get uranium series ages that span from very young to the
24 limit of the method, which is 500,000 years, and then we get
25 the uranium lead ages that go to 1.8 million years.

1 It was this relationship that led to the concept
2 that we're dealing with, very slowly depositing material and
3 that a given thickness of these things represents a long
4 amount of time.
5 So that the challenge here is sampling for dating.
6 You will see in the next slide that we're looking at one to
7 four millimeters per million years. Now, we have to
8 physically sample these with a demo drill, so we're
9 integrating -- our samples will integrate over a finite
10 period of time and the results then will be skewed as a
11 function of the decay constant of the method being used.
12 And an example would be if you had two layers of
13 calcite, one that was modern and a subjacent layer that was
14 a million years old and your sample included both of those
15 layers, that composite sample would be 50 percent modern
16 carbon and your age would be, what, 6,000 years, your
17 determined age, but the real average age would be a half a
18 million years.
19 So that's the kind of bias you can get in the age
20 work in dealing with the shorter half-life systems.
21 Now, when we go to the uranium lead system, it's a
22 much longer half-life, so we're getting much closer to the
23 real mean age of the material sample and the histogram on
24 the left gives the current distribution of ages we have.
25 There is this older calcite layer that's

1 associated with this limpid quartz and some of that has
2 enough uranium to date and the oldest age we've gotten so
3 far is ten million years.
4 Then it progresses up and I think the histogram is
5 more of a function of how we've sampled what we've
6 emphasized than it is a statistical distribution of ages.
7 And this shows the data that have gone into the
8 interpretation of the growth rate. In the upper right-hand
9 corner is a cross-section of a sample and, again, the green
10 fluorescence is opal.
11 This has opal embedded in it and opal on the
12 outside. You'll see an age around seven million years at
13 the base and then 4.5 and 4.3 and I can't even read them all
14 myself, .14 and .09 at the outer surfaces.
15 So here is an example of what we call the micro
16 stratigraphy and in this case, we seem to have it calibrated
17 with ages.
18 Right below that, you will see a series of lines
19 associated with data and these represent different specimens
20 for which we have these same type of data and what we've
21 done is just taken the thickness and normalized the
22 thickness to unites.
23 So plotted on the Y axis is just relative position
24 in a crust or deposit and then the slope of that line you
25 can calculate back and get some estimates of average growth

1 and those go from 1.3 to 4.1 per million years. So we think
2 they're very slow growing.
3 This was verified by some work that was recently
4 done on what's called the SHRIMP, USGS Stanford SHRIMP, in
5 Stanford, and this is the high resolution ion mass
6 spectrometer, where you can actually zap a sample with, say,
7 a 10 to 20 micron diameter beam, you have a beam of oxygen
8 ions, and get ages directly without having to go through
9 sampling or chemistry.
10 So that other diagram, up at the top there, you will see a
11 deposit of opal, one of these hemispheric opal deposits,
12 which is in the outer-most surface and that traverse has
13 ages ranging from 5.1000 at the outer-most zapped point to
14 530,000, but with a huge uncertainty. Anyway, the graph
15 below that plots that data and, again, the growth rate there
16 for that opal using those numbers is .72 millimeters per
17 million years.
18 So this substantiates our contention that these
19 are very slow growing deposits.
20 Fluid inclusions, Jean and Yuri have already
21 covered this. Joe sees the same thing that everybody else
22 does, single phase liquid filled inclusions, single phase
23 gas filled inclusions, two phase with variable liquid gas
24 ratios, and then the two phase was small, but consistent
25 vapor-liquid ratios.

1 And with certain assumptions, these may provide
2 estimates of depositional temperatures.
3 I think it's appropriate to comment here that when
4 the major fluid inclusion thrust started, and I think Jean
5 would agree that there was a lot of discussion on whether
6 calcite was a suitable host for these fluid inclusions,
7 whether calcite could be relied upon, because it was known
8 from other studies that you look at the mineral crosswise
9 and you're going to do something to the fluid inclusion.
10 So there was a lot of discussion and I guess being
11 a skeptic, I'm still somewhat skeptical, but I'm willing to
12 be proven wrong.
13 Anyway, as Jean said, we find also 50 percent
14 inclusions contain deposits, contain fluid inclusions 40 to
15 80 degrees C. Many of these are in the earliest calcite. A
16 few appear to be in the intermediate stage. None have been
17 found in the latest calcite.
18 We think the fluid inclusion assembly is
19 consistent with calcite formation under vados conditions,
20 but at slightly elevated temperatures. In other words,
21 unsaturated conditions. Yuri would say that these all
22 formed in the sat -- that there was saturation, that these
23 fractures were filled with water. We don't agree with that.
24 MR. HORNBERGER: But you would still have to have,
25 as Jean said, a model, a conceptual model for getting the

1 elevated temperatures.

2 MR. PETERMAN: That's true, right. Absolutely.

3 If we can believe the elevated temperatures. I think one

4 has to ask that question first and foremost, and then we

5 have to ask how could you get those elevated temperatures.

6 We know that you can, you know, 12.7 million years

7 and probably a few decades after that, things were very hot.

8 We find evidence fumerolic deposits at the top of the

9 Topapah Spring that are 12.7 million years old, no doubt

10 about it. Just like the Valley of 10,000 Smokes, the water

11 was getting very hot as it penetrated a little bit and the

12 tuffs cooled and crystallized from the top down and there

13 was water circulating and coming back out as very vigorous

14 hot springs and steam vents and all that.

15 There is no doubt about that whatsoever. Then the

16 question is how long did it take to cool the tuffs, say, to

17 50 degrees. I don't think we have a good handle on that.

18 There is a Timer Mountain Caldera, which you

19 referred to -- it's usually quoted about 10.5 million years,

20 called the Timber Mountain Event. Brian Marshall has done

21 some thermal modeling and shows that at Yucca Mountain, 20

22 kilometers away from a possible buried pluton, there is a

23 thermal pulse that could hit Yucca Mountain about eight

24 million years ago and then that has to decay down.

25 Now, it's a very simple model, it's conduction

1 only, there's no advection and all that. It's something
2 that needs to be pursued.
3 MR. WYMER: We are starting to push our time a
4 little.
5 MR. PETERMAN: Okay. I'm going to finish real
6 quick. This is just another example of distribution of
7 fluid inclusions that Joe Whelan did. This is from one
8 little teeny chip, 320 measurements. He's got the patience
9 of Job, 54 degrees. There are some flyers out there, up to
10 80 degrees, 54 degrees, excluding those, standard deviation
11 of three.
12 This bothers me a bit. Two standard deviations of
13 six, total range of 12 million years. If we can measure
14 these things to better than a degree, why do we get this
15 dispersion. It's telling me there are some other variables
16 in here we don't fully understand.
17 This is the USGS data now plotted against distance
18 from the north portal. Those higher temperature values that
19 Jean referred to in the north ramp around 80 to 90 degrees.
20 Again, that's just a map showing the USGS data.
21 Our attempt to constrain ages, this was asked and, again, so
22 far, all we've done is try to sample opal that's immediately
23 above a zone that contains fluid inclusions.
24 We have ten ages now, our youngest age is 1.9
25 million. All of the others fall between eight and nine

1 million, here is one that's seven, okay, 6.5 or seven.
2 Again, they only provide a minimum age and the maximum age
3 is controlled by the tuff.
4 So I would say on the right, the fluid inclusions
5 are between 6.5 and 12.7 million years old. On the left,
6 they're between eight and 12.7 million years old, and this
7 one sample has this bounding opal at 1.9.
8 So as I say, I think we have ten numbers now and
9 this is something that both UNLV and the USGS is pursuing
10 vigorously.
11 These are our conclusions. We have large and
12 comprehensive data that shows that low temperature fracture
13 minerals form from meteoric water percolating downward
14 through the rock mass during the last ten million years or
15 longer.
16 I think the fluid inclusions may provide very
17 interesting information on the thermal history of the rock
18 mass and I think that's something that should be pursued as
19 best we can.
20 So that's it.
21 MR. WYMER: Thank you very much. Are there
22 questions? Surely our geochemist must have a question.
23 MR. DUBLYANSKY: I have a question. Do you have
24 conceptual model for high temperature calcite formed in the
25 vados zone, how much did it happen? I didn't quite

1 understand your answer.

2 MR. PETERMAN: Our contention is that those

3 temperatures are real and I still think we have to be a

4 little bit skeptical, because of uncertainties, assumptions

5 and all that, but those temperatures are real, then that

6 means the rock had to be that hot to heat the downward

7 percolating water.

8 Now, these could be -- it doesn't just have to be

9 done by the cooling of the tuffs. As I say, there is

10 certainly a potential of an eight million year thermal

11 coming from the buried pluton in the Timber Mountain

12 Caldera.

13 There are other ways to move heat into the upper

14 crust. One way is detachment faulting, which is well known.

15 You bring hot rocks up along shallow dipping normal faults

16 below cool rocks and you have a perturbation of the

17 geotherm.

18 And we know that detachment faults are not at all

19 uncommon in southern Nevada. There's a whopper of one just

20 across Crater Flat over at Bear Mountain that did exactly

21 that and that area over there, based on geo chronology,

22 there was activity as young as eight million years.

23 So I think there are certainly ways to get heat

24 into the unsaturated zone without pumping up hot water.

25 MR. WYMER: Well, John Garrick always likes to

1 drive to the very practical end of things, so what does this
2 all mean with respect to Yucca Mountain.
3 I think I understand what each of you concluded,
4 but is there any of the three of you that believe that there
5 is a chance that hydro thermal water is going to come up and
6 fill the cavities? That's your position, that that's a
7 possibility.
8 So of the three of you, there's -- you want to
9 vote?
10 MR. PETERMAN: I think we have to leave it up to
11 the scientific community to evaluate these results and make
12 their own conclusions. We've already made ours.
13 MR. WYMER: How far off are we of having these
14 answers in time?
15 MR. PETERMAN: I would say less than a year.
16 MR. WYMER: Less than a year. You have another
17 presentation? I'm sorry, Yuri.
18 MR. DUBLYANSKY: Just I will be trying to
19 summarize what can be hypothesized about the sources of
20 those fluids and the origin of minerals from the data which
21 are available now.
22 So if you have more data or some new data that
23 will show up, we will probably incorporate them into the
24 model.
25 But I base my presentation on what was done by

1 USGS at least what was available to me and on my new fluid
2 inclusion research was done just recently during this year.
3 So I'm not sure about this idea about heating the
4 rock due to faulting or thermal process. The calculation
5 done for Yucca Mountain and as soon as I have this more
6 formalized model, I will be happy to make an assessment of
7 that.
8 We did, however, estimate the time required for
9 cooling of tuffs and the age of the bedrock is about 12.7
10 million years, and our very conservative estimates show that
11 the cooling would require a maximum of about 100,000 years.
12 So essentially we attribute the formation of this
13 elevated temperature to the cooling of tuff, we have to have
14 the age of this calcite to be close to this 12.7 million,
15 12.8, but it cannot be -- it cannot last for millions of
16 years.
17 Then we have this very well known Timber Mountain
18 Caldera hydrothermal, which is dated from 11.5 to ten
19 million years ago, and this work was extensively studied and
20 dated like that. So we have another time marker here. And
21 then if we see that our sample or our elevated temperature
22 calcite was formed at the time after that, I cannot see of
23 any other explanations than to attribute it to the thermal
24 activity, hydrothermal activity, because again, I repeat, I
25 cannot see how it can conductively heat the rock to such a

1 high temperature.

2 Also, we will continue with further -- we not only

3 have to heat it, but also if we find all the data, we have

4 to maintain this temperature for very long periods of time,

5 and I will come to this later.

6 From the data which I had, I didn't have this new

7 data that they measured ages of the quartz at ten million

8 years, but these preliminary data indicate the age of the

9 oldest -- by that, I mean the oldest ages measured from the

10 Yucca Mountain samples. They were about nine million years

11 old.

12 So they're still somewhat younger than the Timber Mountain

13 Caldera hydrothermal, and this new age is also between ten

14 and nine million years.

15 So I think this makes -- this shows that the

16 minerals that we're talking about, they are younger than --

17 probably younger than Timber Mountain Caldera, but also they

18 are definitely younger than the bedrock tuff, and this is

19 the quote from one of the USGS reports and they seem to be

20 aware about that.

21 MR. HORNBERGER: Yuri, you disagree that those

22 ages represent a minimum age then.

23 MR. DUBLYANSKY: Well, minimum age, as far as I

24 understand, talking about uranium series dating, which are

25 more short-lived isotopes.

1 Would you say that uranium lead ages also provide
2 minimum estimates of that, of ages?
3 MR. PETERMAN: The ten million years is on the cal
4 simulator.
5 MR. DUBLYANSKY: Right. The question was --
6 MR. HORNBERGER: But I understood Zell's point to
7 be that you're sampling an interval and --
8 MR. PETERMAN: We're sampling an interval, but
9 because of the long decay constant for the uranium, we're
10 still getting an average age, but it's closer to the real
11 age of that material.
12 MR. DUBLYANSKY: On these graphs, I plot the
13 thermal reconstruction of the Timber Mountain Event done by
14 Bish and Aronson, these red arrows, and this work was done
15 based on the transition between clay species.
16 And the red rectangle shows the temperature, which
17 was obtained from the ESF samples.
18 You can see it's quite different, 85-90 degrees
19 Centigrade at Yucca Mountain, just ten degrees short of
20 boiling at this altitude. If you just assume normal thermal
21 gradient, conductive thermal gradient, which should be
22 operational in the vados zone, you will have here a gradient
23 of about 200 degrees Centigrade per kilometer, which I don't
24 think is reasonable.
25 So I don't think by conductivity they can raise

1 the temperature to 90 degrees at depths of about 50 or 30 or
2 100 degrees from the surface and keep this temperature for a
3 long time and I don't see how can we do that without melting
4 the rock.
5 Now, let's discuss a little bit ages. First, we
6 have this time marker -- well, mostly, the minerals which
7 can be dated at Yucca Mountain is silica. We only can date
8 the latest calcites which can be dated by uranium series
9 ages, but all calcite cannot be dated because it doesn't
10 seem to be old enough.
11 So we have to use some indirect methods,
12 particularly in those samples that do not contain silica
13 phases.
14 However, it is well known or established at Yucca
15 Mountain that opal is always younger than ten million years,
16 or probably eight million years, and the diagram which Zell
17 was showing, it's clearly demonstrated that.
18 When you talk about opal, you are talking about
19 something between eight million years and probably a 100,000
20 years, and, again, I refer to the work done by USGS.
21 So if we see fluid inclusions associated with this
22 late opal, we have to assume that this calcite is also
23 young. This is one example of the situation.
24 This is calcite and this -- calcite, opal, which
25 is typical young opal which occurs normally in the upper

1 part of the samples, and this is one of the fluid inclusions
2 with a gas bubble here.
3 This is only one inclusion from a group of
4 inclusions which can provide quite reliable temperatures.
5 So in this case, we have to accept that this
6 calcite cannot be older than eight million years.
7 Here is another example and it's a very
8 interesting sample. Again, we have opal in the crust of
9 calcite, which is about one and a half centimeter. One of
10 the opal from the samples collected from this area --
11 actually, there was extensive dating of these samples and
12 the ages obtained range from six million down to 300,000
13 years or something like that. Opal from the samples
14 collected from those cavities.
15 Again, if we accept this rate of deposition which
16 was determined by USGS, which is from one to four millimeter
17 per million years, we have to assume that the time required
18 for generating this crust would have been at least between
19 four and ten million years.
20 Each millimeter of this calcite requires about a
21 million years to grow. It's quite a long time to form that.
22 So what I did, I analyzed calcite layer by layer,
23 above the opal and from outside layers, and here are the
24 temperatures.
25 So basically this part probably are secondary

1 inclusion, but those are very consistent temperatures, 50 to
2 52 degrees Centigrade, and these temperatures just
3 persistent through the all the crust.
4 Again, it's a little bit -- well, it isn't
5 contradiction, which Jean was showing, that fluid occurs
6 only in the bottom. These particular samples, you can see
7 fluid inclusions throughout the crust.
8 MS. CLINE: You can't equate position necessarily
9 to age. I guess what I'm saying is that I don't agree 100
10 percent. You can't just measure some thickness, attribute
11 some number of years. You can have a whole crust that grew
12 ten million years ago. You can have a whole crust that grew
13 a million years ago.
14 MR. DUBLYANSKY: Exactly that is my point, but I
15 am not very comfortable with this rate of one millimeter or
16 four millimeter per million year. I just kind of
17 exaggerate, but still my point is here in this crust, we
18 have consistent temperatures throughout the crust and if
19 these rates are correct, we have to assume like eight
20 million years timeframe of this growth.
21 I'm not saying that that's what was happening.
22 I'm just showing some kind of problems with that. But,
23 again, these temperatures are very consistent and is present
24 in all calcite. This calcite looks to me very typical
25 bladed calcite.

1 The next method which we can use is to use stable
2 isotope, like Zell was suggesting, and this is a compilation
3 of data. Well, it's kind of illustration of data which is
4 represented in the one of the USGS reports.
5 Indeed, this report says that early calcite,
6 probably old calcite almost always have this heavy carbon
7 and it's light in oxygen and late calcite almost always have
8 the reverse, light carbon and heavy oxygen.
9 Late calcite form will define between minus five
10 and minus eight per mil and this calcite generally
11 represents the age distribution over the last several
12 hundred thousand years. That is according to the work by
13 USGS.
14 So if we have calcite which have these values, we
15 probably, again, if we accept this idea of USGS, we have to
16 accept that we are talking about calcite over the age of a
17 few hundred thousand years.
18 So here is one of my samples which I studied.
19 This calcite does not contain opal, so it cannot be dated,
20 but it does contain fluoride, not a very typical mineral in
21 water, and it consists of three zones; base zone, granular
22 zone, and then blocky calcite.
23 So I did a very detailed and very careful isotopic
24 study on this calcite, actually the same thing just turned
25 90 degrees clockwise.

1 I used the in situ laser ablation stable isotopic
2 analysis and with a spatial resolution about 300 microns for
3 each spot.
4 Some of this delta C-13 stays positive for the
5 most part of the crust and the outer part, it drops
6 dramatically to the values of minus six to minus eight,
7 which are the typical values which were reported as being
8 representative of the calcite with the age of on the order
9 of a few hundred thousand years.
10 So this essentially carbon oxygen distribution
11 from this particular sample, one sample, essentially mimics
12 what was shown by USGS. Again, we have this late calcite
13 with consistently light carbon and heavy oxygen.
14 So again, if we accept this USGS interpretation,
15 we have to assume that this calcite was formed less than
16 probably 200,000 years ago.
17 Here are the results. Again, we have fluid
18 inclusions through all the crusts from top to bottom and
19 this early calcite, heavy carbon calcite, shows a little bit
20 more high temperature and this late calcite has a little bit
21 cooler temperature, but still the thermal temperature is 40
22 to 46 degrees, 50 to 52 degrees.
23 So in this situation, we have isotopically light
24 calcite, which is probably formed at early -- probably young
25 and it does contain fluid inclusion and in this case, again,

1 we have fluid inclusion present throughout the crust.
2 So my point is that at this point, at this stage,
3 we cannot claim that all fluid inclusions or all calcite
4 contain elevated temperature. We cannot claim that this
5 calcite is related to the cooling of tuffs because the age
6 data does not allow us to tell that, and I think the only
7 interpretation of that is that this calcite was formed by
8 fluids with elevated temperature within the mountain.
9 Thanks.
10 MR. WYMER: Thank you. Questions?
11 MR. PETERMAN: I just have a comment. If you look
12 at page 12 on my handout, you will see that many, many
13 hundreds of carbon and isotope analyses, they form a very
14 broad trend and within each group, there is -- maybe it's
15 not 12. It's the one that has the carbon versus oxygen.
16 There it is.
17 There's a huge amount of scatter there and other
18 than saying there is a real trend, I don't see how you can
19 use that data, except in the very earliest calcite, which is
20 below the base cal simulator, which has those anomalies or
21 very light oxygen values.
22 I don't see any way how you can use that cluster
23 of data as a chronometer at all. It's just way too much
24 scatter.
25 MR. DUBLYANSKY: My answer will be, first, that

1 this graph which you represent here on your handout -- I
2 just remembered the graph from your presentation, which
3 brackets the temperature of 50 to 80 degrees Centigrade and
4 those brackets are around the red dots, which are heavy in
5 carbon and light in oxygen.
6 It's just not correct, because I just have shown
7 you that temperature 50 degrees Centigrade and 55 degrees
8 Centigrade can be associated with calcite which should be on
9 this blue.
10 MR. PETERMAN: But you had no age information to
11 constrain that statement whatsoever.
12 MR. DUBLYANSKY: That's exactly, but the statement
13 which you made in your report, they have no bearing on age.
14 You just refer signature and age. Always, when you report
15 stable isotopic values of this and carbon is minus five to
16 minus eight.
17 MR. PETERMAN: Joe's depiction there is based upon
18 petrographic delineation of the paragenetic sequence.
19 That's his categorization.
20 Any one specimen, there may be age controls, but
21 he just put together the paragenetic sequence and then he's
22 put the carbon and oxygen isotopes in that framework.
23 MR. DUBLYANSKY: Absolutely, but I also have a
24 paragenetic sequence in my sample and I just have shown it
25 to you.

1 MR. PETERMAN: But you had no age information.
2 MR. DUBLYANSKY: Indeed, I don't have age
3 information, but I do have indication that -- at least I am
4 using your information and your work, actually I quote this
5 in my report, that -- let me just quote you.
6 MR. PETERMAN: It's not going to do me any good.
7 I certainly can't remember the paper quotes at this point in
8 time. But there are typically a lot of things that are
9 taken out of context.
10 MR. DUBLYANSKY: Well, this work is based only
11 stable isotopes and it summarizes stable isotope work and
12 age dating work.
13 So I'm just using your information.
14 MR. PETERMAN: The same diagram is published
15 somewhere in another report and I would suggest maybe you
16 use that distribution of value.
17 MR. DUBLYANSKY: I didn't understand your comment.
18 MR. PETERMAN: I don't know what report that is.
19 It may have been 1992?
20 MR. DUBLYANSKY: No. This is the report, ages and
21 origin of subsurface calcite, and what I did is I just took
22 date from your table and quoted them. That's all I did.
23 MR. PETERMAN: That's fine. That's a general
24 trend. But if you put the uncertainty on that trend, it's
25 huge.

1 MR. HORNBERGER: I think Zell was just saying that
2 you can't invert that trend, because if you look at his
3 dots, the 13 on the early calcite goes everywhere from plus
4 ten to minus six. It's not very well constrained. It's a
5 trend, but you can't use it as a geo thermometer.
6 MR. DUBLYANSKY: I am not intending to use it as a
7 geo thermometer.
8 MR. HORNBERGER: Or a geo chronometer, sorry.
9 MR. DUBLYANSKY: Or geo chronometer, too. What I
10 want to show, we have to have some handle on the -- well,
11 I'll put it a different way. We probably cannot date this
12 calcite because it cannot be dated with the uranium lead
13 methods. So should we just throw away the data, fluid
14 inclusion data, which we obtained on this calcite? I don't
15 think we should do that.
16 So I am using this stable isotope data as as proxy
17 of the ages, again, based on the work done elsewhere by
18 USGS.
19 I understand that that it's not a perfect method
20 and I will not claim that. But at least we cannot claim, by
21 the same token, that this calcite is old.
22 MS. CLINE: Do you have paragenetic data that show
23 that that particular calcite that forms the outer band in
24 that sample is consistently present and is consistently a
25 young calcite throughout the repository site?

1 MR. DUBLYANSKY: No, I don't, because it's blocky
2 calcite. It is present -- well, it could be present in many
3 samples. There's a granular calcite in the middle, which I
4 was showing it's not very common Yucca Mountain calcite at
5 all, also it contains fluorides, which also not all samples
6 are -- not all samples contain.
7 So I think paragenesis also should be variable
8 from place to place in Yucca Mountain. For instance,
9 fluoride, we have found that fluoride is mostly associated
10 with samples that are collected close to the fault lines.
11 MS. CLINE: Close to the fault lines?
12 MR. DUBLYANSKY: Right, close to the major fault
13 lines and we have found fluoride in many, many samples, in
14 much more samples that we expected to find them.
15 No, I cannot parallel this particular calcite as
16 paragenesis and that's why I'm using -- I am trying to use
17 stable isotope report to get a handle on where I can place
18 this calcite.
19 MS. CLINE: I would just say that in the work we
20 have done on all the samples where we see the fluoride, it
21 is in an older part of the sample. We have not seen
22 fluorite anywhere we can constrain the fluoride as being
23 part of the younger event, either the later belated event or
24 the magnesium enriched calcite. It's just not there.
25 MR. DUBLYANSKY: Yes, but I don't think you have

1 an age constraint on the calcite either.

2 MS. CLINE: This is relative age.

3 MR. DUBLYANSKY: Relative age. In terms of

4 relative age, well, this fluorite definitely is present in

5 this zone and the outer zone of calcite, and here you can

6 see fluorite just protrudes into the surface of calcite.

7 It's a common calcite and fluorite. Again, basically, it's

8 one way of addressing this issue, to calculate the

9 thermodynamics of the calcite-fluorite system and that's

10 what we are doing right now.

11 MR. WYMER: According to my schedule, we're over

12 with our break now. Is there one last burning question or

13 comment? It's a very interesting discussion. Is there any

14 final thing that one of you feels constrained to say?

15 If not, well, thank you very much. It's an

16 interesting discussion. Let's take a break.

17 MR. GARRICK: Yes. Thank you. Before you break,

18 I want to advise you of what we're going to do. There's two

19 things remaining to be done.

20 One is to prepare the committee for the tour

21 tomorrow and the other is simply to do some homework in

22 preparation for future meetings. I don't think we need the

23 court reporter for the rest of the day. So I'm getting a

24 favorable head nod from the staff, so you are excused, as we

25 adjourn for the break.

1 [Whereupon, the meeting was concluded.]

2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25

CERTIFICATE

This is to certify that the attached description of a meeting of the U.S. Nuclear Regulatory Commission entitled:

TITLE OF MEETING: ACNW 121st MEETING

PLACE OF MEETING: Las Vegas, Nevada

DATE OF MEETING: Wednesday, September 20, 2000

was held as herein appears, is a true and accurate record of the meeting, and that this is the original transcript thereof taken electronically by me, thereafter reduced to typewriting by me or under the direction of the court reporting company

Transcriber: Natalie Renner

Reporter: Audrey Johnson