

ACNWT-0143

BEFORE THE
UNITED STATES NUCLEAR REGULATORY COMMISSION

PROCESS USING ADAMS
TEMPLATE: ACRS/ACNW-005

123RD MEETING OF THE ADVISORY COMMITTEE ON NUCLEAR WASTE

NOVEMBER 29, 2000

**ACNW OFFICE COPY - RETAIN FOR
THE LIFE OF THE COMMITTEE**

Center for Nuclear Waste Regulatory Analyses
6220 Culebra Road, Building 189
San Antonio, Texas

ELLEN WALTERS, CSR
(817) 589-7648

TRO8

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25

P R O C E E D I N G S

MR. GARRICK: The meeting will come to order. This is the third day of the 123rd meeting of the Advisory Committee on Nuclear Waste. The entire meeting will be open to the public.

Today the Committee will tour the Center's experimental facilities, discuss the investigation and importance of ongoing Center-coupled processes related to repository design, and discuss miscellaneous matters related to reports.

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

The Committee has received no written statements or requests to make oral statements from members of the public regarding today's session.

Should anyone wish to address the Committee, please make your wishes known to one of the committee staff. And it is requested that each speaker use one of the microphones, identify themselves and speak clearly.

Okay. We're now going to just deal with the agenda item that's labeled, "Investigation and Importance of Coupled Processes Related to Repository Design," and

1 the Committee member that has the lead in this area is Ray
2 Wymer.

3 MR. WYMER: I was pleased to hear yesterday
4 from the DOE representative that they now consider that
5 coupled processes are important and in fact may be one of
6 the most difficult issues that they have to address. As
7 many of you know, the Committee has been saying that for a
8 long time.

9 So this morning we're going to hear and discuss
10 reports of coupled processes related to alloy waste
11 repository performance.

12 I presume we'll have still the full hour and a
13 half, having lost 15 minutes this morning of the talk, I
14 think we can still take the full hour and a half for this
15 presentation.

16 So if our first presenter will come forward and
17 introduce themselves, we'll get on with it.

18 MR. PABALAN: Good morning, ladies and
19 gentlemen. My name is Bobby Pabalan from the Center for
20 Nuclear Waste Regulatory Analysis.

21 This morning my colleague Debra Hughson and I
22 will talk about the NRC and Center studies related to
23 coupled processes as it affects repository performance.

24 The second viewgraph shows my outline. After a
25 brief introduction, I will provide a short summary, a

ELLEN WALTERS, CSR
(817) 589-7648

1 history of the Center and NRC studies of coupled
2 processes, as well as the objectives of these studies.

3 And then Debra will follow with a discussion of
4 Center studies on effects of coupled processes and seepage
5 and flow.

6 Then I will come back and talk to you about the
7 Center studies related to the effects of coupled processes
8 on near field chemical environment, and I will follow up
9 with a summary.

10 There is a general consensus in the literature
11 that we need appropriate couplings of thermal, hydrologic,
12 mechanical and chemical processes in safety evaluations of
13 geologic repositories for nuclear waste.

14 NRC staff and Center staff believe that we need
15 to consider thermal loads when evaluating mechanical
16 processes in groundwater flow, and we think that the DOE
17 will need to have an acceptable methodology for
18 systematically considering thermal loads and thermally-
19 induced mechanical, hydrologic and chemical processes for
20 the design and performance of a geologic repository.

21 I've listed in the third viewgraph -- fourth
22 viewgraph the principal factors of the DOE repository
23 safety case as outlined in their Revision 3 of the RSS and
24 note that five of the first five, seepage into the drifts,
25 performance of the drip shield and waste package,

ELLEN WALTERS, CSR
(817)589-7648

1 solubility of the radionuclides and retardation in the
2 unsaturated zone, we believe will be affected strongly or
3 can be affected strongly by coupled processes.

4 The area of coupled processes and studies
5 related to these have been of interest to the NRC and
6 Center staff even early on in the NRC program at the
7 Center.

8 Almost ten years ago, we did a systematic
9 literature review with respect to coupled THMC processes
10 that could be pertinent to the proposed Yucca Mountain
11 repository. This review was published sometime in 1992.

12 Our of this literature review, a number of
13 recommendations were made. For example, it recommended
14 the development of conceptual and mathematical models
15 beyond those that were available at that time.

16 It also recommended performance of well-
17 documented coupled-effect experiments, as well as
18 validation of models through comparison of model
19 predictions and experimental observations.

20 Specific recommendations also include looking
21 at synergistic effects between chemical reactions and mass
22 transport under thermal conditions, as well as looking at
23 mechanical stability of underground excavations under
24 varying thermal and hydrologic conditions.

25 This set of recommendations was used as some of

ELLEN WALTERS, CSR
(817)589-7648

1 the basis for future work that the NRC and the Center have
2 conducted in succeeding years and which we still do up to
3 this point.

4 We did a number of studies looking at
5 thermohydrology, thermochemical processes and
6 thermomechanical studies. One of the early research
7 projects that we had at the Center funded by the Office of
8 Research at NRC was on thermohydrology. I believe this
9 project was initiated way back in 1989.

10 Specifically, we looked at through laboratory
11 experimentation and computer simulations the thermally
12 driven moisture redistribution in partially saturated
13 porous and partially saturated fractured media.

14 We also looked at the possible geochemical
15 conditions in a heated geologic repository in one of our
16 research projects also in geochemistry.

17 One of the more recent studies done here at the
18 Center was to look at the drift stability and ground
19 support performance under thermal and dynamic load in
20 fractured rock mass. This was just published this year.

21 From my perspective, this study in
22 thermomechanical drift stability is very interesting, not
23 only the machination, but the conclusion of the study is a
24 good example.

25 The results are in contrast or contrary to one

ELLEN WALTERS, CSR
(817)589-7648

1 would expect based on experience in conventional mining
2 and tunneling.

3 The bottom line is the results indicate that
4 thermally-induced rock mass deformation of highly
5 fractured rock masses will be greater than the deformation
6 of lower quality rock mass, which is in contrast to what
7 one would expect based on conventional mining and
8 tunneling experience. Lower quality rock mass would
9 undergo greater deformation, and the results here are in
10 contrast to that.

11 The previous studies that we have conducted
12 focused mainly on either two-way coupling, for example,
13 the thermohydrology studies, or in one-way coupling with
14 respect to thermochemical and thermomechanical.

15 The last two bullets, we looked at the effects
16 of temperature on the chemistry. We looked at the effect
17 of temperature on mechanical stability.

18 It wasn't until we started the development of a
19 fully-coupled THC computer code, which we call MULTIFLO,
20 that we were able to simulate fully-coupled THC processes
21 in one, two, three dimensional, 3-D special dimensions.

22 MULTIFLO allows us to model liquid and gas
23 flow, heat transport, chemical transport, equilibrium
24 speciation, as well as kinetically controlled mineral
25 precipitation and dissolution.

ELLEN WALTERS, CSR
(817) 589-7648

1 Since the development of this MULTIFLO code, it
2 has been a major tool for several of the NRC/Center KTI
3 activities. We have used MULTIFLO to look at near drift
4 THC effects on flow.

5 We have looked at ambient and thermally
6 perturbed geochemical environments, seepage into drifts,
7 as well as mountain-scale unsaturated flow under ambient
8 and perturbed conditions. We've also looked at 3-D
9 groundwater flow in natural thermal gradients.

10 In addition to those process level types of
11 calculations, we have abstracted the results of those
12 studies into our TPA code in most cases in the form of
13 look at tables, for example, for concentration and the
14 near field environment that could affect waste package
15 performance.

16 The Center and NRC has also determined, based
17 on previous studies, that incorporation of fully coupled
18 thermal-hydrologic-mechanical-chemical processes, which
19 means fully coupling of THMC, was determined not to be
20 necessary for assessment of repository performance.

21 In other words, we can look at the couplings of
22 these four processes two-way or maybe three-way, but we
23 don't need to look at four-way couplings for those
24 processes.

25 Now, the Center and NRC studies on coupled

ELLEN WALTERS, CSR
(817) 589-7648

1 processes is being done in a risk-informed performance-
2 based manner.

3 It means that we're not looking at all possible
4 coupled processes. We cannot because of resource
5 constraints. We have to focus on those that we believe
6 will be important to repository performance.

7 The objectives of these studies are to test the
8 validity of the assumptions and to probe the technical
9 uncertainties of the DOE models and abstractions.

10 These studies also allow us to quantitatively
11 assess the adequacy of the DOE safety case and the
12 reliability of the DOE estimates of repository
13 performance.

14 At this point I'll turn over the podium to
15 Debra Hughson, who is going to talk about the coupled
16 processes in seepage and flow.

17 MS. HUGHSON: Good morning. I'm Debra Hughson.
18 I work here at the CNWRA, and as usual, these things
19 advance too quickly.

20 I have three things I really want to talk about
21 this morning. The first one on the bottom here is the
22 laboratory work that I did to investigate a small scale
23 process to see if water can actually get through the above
24 boiling zone and arrive at the drift wall during the
25 thermal period.

ELLEN WALTERS, CSR
(817) 589-7648

1 And then depending on the time constraints, I'd
2 also like to mention some work that was done by some
3 colleagues of mine regarding the effects of
4 thermomechanical effects. The issue there is that the DOE
5 would like to ignore thermomechanical effects.

6 And then I'd like to also, if I could, talk a
7 little bit about some work that Scott Painter has done
8 with regard to the coupling of a thermohydrological
9 chemical.

10 And the concern there is that our models really
11 are showing something a little bit different than what the
12 DOE's models are showing, and we'd like to look into that
13 a little more.

14 This is some lab work that I did. The issue
15 here is can water in the reflux zone focus by
16 heterogeneity or gravity fingering into rivulets and
17 actually flow through the above boiling zone and arrive at
18 the drift wall.

19 And so what I did is I put together a Hele-Shaw
20 model, which essentially you're looking at two plates of
21 roughened glass that are pressed together and then we put
22 heater strips on the back side here, these little brown
23 things, so that we could increase the temperature going
24 from the top down to the bottom.

25 And then we put in a flow rate. Right here at

1 the top we put in flow rates from .01 up to .4 millimeters
2 per minute.

3 Now, the little thermocouples here on the
4 front, these little white dots, you can see we're looking
5 at what the temperature is on this Hele-Shaw model.

6 Now, right at this point here, you can see this
7 is where the temperature was 100 degrees boiling before we
8 started injecting the water.

9 Then as we injected the water here, we wound up
10 getting the condensation up here in the cooler region, a
11 two-phase zone here where gas vapor is rising and gravity
12 drainage fingering down into the above boiling region.

13 Then where the infiltration was focused in, we
14 wound up getting infiltration clear down to the point
15 where the temperature was about 140, 145 C.

16 We have a model of this in our TPA code, given
17 some work done by O.M. Phillips, which shows that the
18 length that this can flow into the above boiling zone is
19 the square root of the density of the water, the flow
20 rate, phase change, thermal conductivity of the medium and
21 the temperature gradient of the increasing temperature.

22 It also has a geometric factor in here and if
23 you go through Phillip's derivation, this geometric factor
24 turns out to be $2/\pi$, which for fractured, the heat is
25 flowing radially around the infiltrating finger.

1 Now, I made some assumptions about one-
2 dimensional heat flow through this Hele-Shaw model and I
3 also assumed that the water was flowing at a constant
4 velocity down.

5 And I wound up getting two models. I wound up
6 getting a numerical model and an analytical model and I
7 was able to back out what this geometric factor was for
8 the Hele-Shaw model. It turned out to be about 1.2.

9 So that's kind of interesting. It shows that
10 even for a fractured rock or for this Hele-Shaw model, I
11 got a geometric factor reasonably close to one.

12 And so I concluded that this was probably a
13 reasonably good model for looking at this small scale
14 process.

15 I tried to combine this then with our dual-
16 continuum MULTIFLO simulations. What you're looking at
17 here kind of fuzzily is the liquid velocity condensate
18 draining and refluxing in the fracture continuum.

19 These are no-flow boundary conditions on the
20 side here and so this essentially replicates this thing in
21 infinity in either direction, which is a reasonably good
22 assumption for the center hot part of the repository.

23 Right in here is where I put the heat source
24 for the drift. This is the centerline, through the
25 centerline of the pillars.

1 The 50 years here, I wound up getting a maximum
2 flow rate above the drift of 150-about millimeters per
3 year, and then you can see the condensate draining down in
4 the pillars where the temperature is below boiling. And
5 the dry-out zone, the distance to the boiling isotherm
6 from the drift crown was 4.7 meters.

7 At 200 years, this dropped off to about 48
8 millimeters per year and the dry-out zone had increased a
9 little over ten meters. And at 500 years, we're back to
10 about 20 millimeters. The boundary condition I put here
11 on the top was 10 millimeters a year in filtration.

12 So we're back down to just about twice the
13 ambient infiltration in the refluxing zone here, and the
14 boiling zone was about 10 meters or so.

15 So you can look at this to get the parameters
16 for this model and you can see that the flux spikes up to
17 about 150 in the first few decades of closure and then
18 decays back down to the ambient level.

19 The dry-out zone, again, spikes up to about 10
20 meters and, again, this is the hotter portion of the
21 repository. The edges are cooler.

22 So then it begins to re-wet and decays back
23 down. This is 2000 years right here, and this is the
24 length in that length scale formula, the distance from the
25 crown to the boiling isotherm.

1 And also, this is the flow rate in there, the
2 maximum flow and the area that it's focused over. So what
3 I can do from this is I can back out the area that you
4 have to focus this refluxing flow over in order to get
5 enough flow in a single rivulet that it will flow all the
6 way to the drift wall.

7 And this is meters squared here and this goes
8 from zero up to a hundred meters squared. This is years
9 from zero to 2000.

10 What this suggests is that if this process is
11 going to occur at the repository, it's most likely to
12 occur early after closure.

13 And then you see you have to focus the flow
14 over quite a large area during most of this thermal period
15 to actually get water to the drift wall.

16 Now, as Bret Leslie pointed out to me, I'm
17 neglecting ventilation in this model, the dry-out due to
18 ventilation. So you might get a little bit of extra
19 protection here because you have some dry-out initially
20 due to the ventilation.

21 Now I'd like to switch gears here and talk just
22 very briefly about some work that was done by Goodluck
23 Ofoegbu. Goodluck was looking at the thermomechanical
24 effects.

25 This is a cross-section through the mountain.

1 These little dots here represent the drifts. Now, this is
2 a weekly coupled model.

3 Goodluck first looked at what effect thermal
4 would have on permeability and then looked at the flow
5 that would happen with those changes in permeability.

6 The story here is that the thermal effect tends
7 to cause tension on the rock formation in between the
8 drifts and the pillar.

9 This tends to open up the fractures which are
10 horizontal and then the bottom line here is that this
11 horizontal fracture dilation appears to cause some
12 elevated flux within and on the downstream side of the
13 thermally-mechanically altered zone.

14 Now, this is a work in progress. You see the
15 scale here is relatively coarse. So these drifts are
16 really reflected by one cell, and so we don't have any
17 information about this causing increases or decreases in
18 flow into the drift.

19 But it does seem to have some effect and so
20 we're looking into this assumption that you can just
21 neglect thermomechanical effects.

22 And finally, I'd like to talk briefly about
23 some work that Scott Painter is doing. This is a strongly
24 coupled model in that the precipitation of mineral species
25 silica changes the permeability and porosity and then

1 those changes in permeability and porosity then go right
2 back to the flow code and they affect the velocity.

3 So this is strongly coupled within a single
4 time step. The chemistry sees the change in permeability
5 and so does the flow field.

6 This is the drift here. This is saturation in
7 the fractures of zero to 20. Over here is the fracture
8 intrinsic porosity, which goes from zero to one.

9 And you can see that at 200 years here we're
10 getting some significant changes in the fracture porosity.
11 Above the drift here, the fractures are really tending to
12 plug up.

13 This is significantly different than what the
14 Department of Energy's models show right now and we're
15 looking into that.

16 The preliminary indications tend to indicate
17 that it may be perhaps the way that we're representing the
18 gas permeability. The DOE is using a modified Cory
19 relationship for gas permeability.

20 We're using the Vanganuken relationship for
21 liquid permeability and then summing the relative
22 permeabilities to one.

23 The process that really seems to be going on
24 here is that the temperature is increasing the pressure
25 within the matrix, which keeps the liquid phase, which

1 increases the boiling point and keeps the water in the
2 liquid phase in the matrix, but it's above boiling in the
3 fractures and the pressure is lower.

4 So as water migrates from the matrix blocks to
5 the fractures, it flashes into vapor and deposits a silica
6 deposit behind.

7 And so we're looking into the difference
8 between the DOE's models and our models to really see why
9 we're getting a different result. But it does appear to
10 be fairly sensitive to the way that we're representing
11 permeabilities of the matrix.

12 And so if there's no questions, I'd like to
13 turn it back over to Bobby to talk briefly about the
14 chemistry.

15 MR. GARRICK: There might be some questions.
16 Ray?

17 MR. WYMER: No. That's quite a load for those
18 of us who aren't very skilled in this area. I think I
19 understand your conclusions pretty well, but I don't have
20 any questions about it.

21 MR. GARRICK: Would your results have been
22 different had you gone to more dimensions in your models?

23 MS. HUGHSON: I believe that the temperatures
24 change with the dimensionality, and you tend to get higher
25 temperatures in two-dimensional models. So in fact, if I

1 looked at a three-dimensional model, I might be seeing
2 some decrease in temperature.

3 In terms of the velocities, I think that is
4 probably reasonably close because we're taking a two-
5 dimensional slice here, and so we're really looking at the
6 dimension between the drifts.

7 This was just replicated along the drift in
8 either direction. So I don't think that we'd see a lot of
9 change in the saturation and the velocities, although
10 again the temperatures might be a little bit different.

11 MR. GARRICK: Have you baselined this for a
12 ventilated repository or cold repository?

13 MS. HUGHSON: Baseline?

14 MR. GARRICK: Well, have you done a similar
15 kind of analysis for where the repository did not have a
16 head load like this?

17 MS. HUGHSON: Well, what I did in these
18 simulations, the MULTIFLO simulations, is I reduced the
19 heat load for 50 percent for 50 years to simulate the
20 effects of ventilation.

21 Now, you see the DOE is reducing the heat load
22 by 70 percent, and we're asking them to back that up with
23 data, and not just a simplified model.

24 Now, what we are neglecting is the removal of
25 moisture from the drift during the ventilation period. I

1 believe, and we haven't looked into this specifically,
2 although we do have some models in progress to actually
3 look at the coupling, but what I suspect is that if you
4 remove water from the drift during the ventilation period,
5 we'd actually remove a little bit more heat, and that also
6 you're removing mass so you would tend to get a little bit
7 of a dry-out zone around the drifts, which may change the
8 results perhaps in a conservative direction.

9 MR. GARRICK: A final question. Is the
10 chemical composition of the water a factor at all in your
11 calculations?

12 MS. HUGHSON: Now, I'm going to say that I
13 believe that it is but I would like a chemist to --
14 perhaps if Lauren, would you like to speak to that?

15 MS. BROWNING: Yeah, sure. I wasn't involved
16 in the particular studies that -- Lauren Browning, CNWRA.
17 Debra and I did some work earlier on it, a different
18 application using MULTIFLO in which we varied the
19 composition of the infiltrating water.

20 We found that it did have a large impact on the
21 types of secondary phases that were predicted, the types
22 of -- the changes in water composition over time.

23 MR. WYMER: I do have one followup question.
24 How far in time are these effects important? When do they
25 stop being important?

1 MS. HUGHSON: Well, now, the work that Scott's
2 done, what I showed you there was 200 years, but the
3 silica cap then persists indefinitely.

4 MR. WYMER: The deposits are there forever.

5 MS. HUGHSON: Yes, the deposits persist
6 indefinitely. The thermal-mechanical effects I do also
7 believe are permanent because what you have is a shifting
8 along the plane of the fracture and the asperities then
9 would change the aperture, average aperture.

10 In terms of the thermal-hydrology, the peak
11 temperatures occur about 200 to 300 years in my model, and
12 I'm winding up getting a rewetting back to ambient
13 conditions after about 2,000 years.

14 Again, this is the hottest part of the
15 repository and the edges would be cooler.

16 MR. WYMER: That's important.

17 MS. HUGHSON: Yes, it is important.

18 MR. WYMER: Thank you very much.

19 MR. LEVENSON: One question. In the Hele-Shaw
20 cell experiments, the water addition rate that you used,
21 where does that fit in the range of precipitation?

22 MS. HUGHSON: Well, again, what we're looking
23 at here is a volumetric flow rate, and what I'm looking at
24 in the models with the infiltration is a linear flow rate,
25 length per time.

1 And so the way that I related the two, the flow
2 rate that I used with the flow rate in the Hele-Shaw
3 model, is by the area that you would have to focus it
4 over.

5 But basically, the point of the Hele-Shaw
6 model, which I'd like to show you on our lab tour, is to
7 look at whether or not Phillip's relationship is valid for
8 this particular process, and then going back to the
9 MULTIFLO simulations to see what kind of linear flow rate
10 we would get and then the area that we'd have to focus
11 that over to reach the drift.

12 MR. LEVENSON: But for such a small finite size
13 area, isn't that somewhat sensitive to the flow rate?

14 MS. HUGHSON: Say that again?

15 MR. LEVENSON: The distribution that you get,
16 your temperatures are fixed. It seemed to me that there
17 might be a significant difference in the liquid
18 distribution, depending on the rate at which you're adding
19 water to the system.

20 MS. HUGHSON: In the Hele-Shaw model?

21 MR. LEVENSON: Yes.

22 MS. HUGHSON: Well, again, the --

23 MR. LEVENSON: At the extreme you can flood it
24 or you have such a tiny trickle that there's nothing. So
25 the question is, how does -- this is representative of

1 percolation coming from precipitation; right?

2 MS. HUGHSON: No. Again, the purpose of the
3 Hele-Shaw model was to look at Phillip's relationship and
4 see if that's --

5 MR. LEVENSON: Yeah, yeah. But if it is
6 sensitive to flow, flow relationship to area --

7 MS. HUGHSON: But again, the relationship of
8 the flow to the area is to go back to the dual-continuum
9 model and see how we can look at the small scale processes
10 with Phillip's link scale given the parameters within the
11 MULTIFLO simulation.

12 MR. LEVENSON: What I'm trying to ask is, was
13 the flow ratio here in the middle of expected conditions
14 or is this a bounding experiment?

15 MS. HUGHSON: Well, again, really neither,
16 because what we're looking at, we look at a range of flow
17 rates from a very small trickle up to something which is
18 quite large, .4 millimeters per --

19 MR. LEVENSON: All in the Hele-Shaw cell?

20 MS. HUGHSON: In the Hele-Shaw cell, so we're
21 looking at a whole range.

22 MR. LEVENSON: Oh, okay, because you just gave
23 one number.

24 MS. HUGHSON: Oh, I'm sorry.

25 MR. LEVENSON: I withdraw all the other

1 questions. The implication was you were at one flow rate.

2 MS. HUGHSON: Oh, I'm sorry. No. We looked at
3 a range of flow rates and a range of temperature
4 gradients.

5 MR. WYMER: Are there any other questions?

6 MR. CLARK: Just following up on what Milt
7 asked. There is an estimate of deep percolation. For
8 different climates there are estimates of how much water
9 will reach the drifts. How does your experiment compare
10 to that?

11 MS. HUGHSON: Well, again, looking at this
12 MULTIFLO simulation, I believe that 10 millimeters per
13 year is somewhere in the range of this expected during the
14 thermal period, the first 2,000 years.

15 And then going back to the Hele-Shaw model, all
16 we looked at there was a range from a very small trickle
17 to up to quite a large flow rate, and the temperature
18 gradient and then looked at that range and how that
19 related to Phillip's link scale.

20 And then we were able to say, well, yeah,
21 Phillip's link scale is probably a reasonably good model
22 for this range of flow rates, and then we looked at the
23 simulations to see the actual conditions at the mountain.

24 MR. EWING: This is very interesting but I'm
25 out of my depth, so maybe this is a silly question. But

1 for coupled systems, I'm always interested to develop a
2 qualitative sense of the source and magnitude of
3 uncertainty.

4 And you offer a very nice example of two
5 conceptual models and with those two models also different
6 barometric values, if I understood correctly. The heat
7 load is different in yours versus DOE.

8 So when you have this situation, is there any
9 way, from your point of view to compare these two
10 conceptual models and quantify the uncertainties and
11 source of the uncertainty?

12 MS. HUGHSON: So are you talking about the
13 dual-continuum simulations?

14 MR. EWING: Right.

15 MS. HUGHSON: Okay. This is a big issue and
16 this is probably the main focus of the TEF, the KTI that
17 I'm involved with, is dealing with uncertainty.

18 And I believe that there is quite a bit of
19 uncertainty which is not accounted for coming from various
20 sources.

21 This is due to the calibrated properties that
22 we use in the models, the inverse method, measurement
23 error, scale effects, spatial heterogeneities, and so
24 there's quite a number of uncertainties, I think, that
25 aren't necessarily captured in the whole overall approach.

1 Now, when you compare our model to their model,
2 well, you probably won't see a lot of difference because
3 we're using their calibrated properties and we're
4 basically using their heat load and so we're getting
5 something fairly similar to what they're getting.

6 But again, this doesn't account for all the
7 uncertainties, nor does their model account for all the
8 uncertainties.

9 MR. EWING: Would that be part of this work to
10 write an essay or provide a list of sources of uncertainty
11 for some discussion of how they fit in?

12 MS. HUGHSON: Actually, yes. I did that for
13 our IRSR this year. In Section 5.3 you can see that I
14 spent a lot of time discussing these various sources of
15 uncertainty.

16 You see what we're doing with the chemists and
17 with the rock mechanics is we're looking at other sources
18 of heterogeneity, which add more uncertainty, and we're
19 looking at that effect on the flow processes, which is
20 something that we're saying, okay, you just can't ignore
21 that. You have to account for the uncertainty or the
22 variability that those processes might cause.

23 MR. CAMPBELL: One question, Debra. In terms
24 of the DOE model that the design where the drifts are hot
25 out to a certain area and then the pillars are cool in

1 between the drifts, I'm not sure that the Hele-Shaw model
2 addresses that specific design.

3 MS. HUGHSON: No. The Hele-Shaw model is not
4 looking at anything in that scale. The Hele-Shaw model is
5 looking at a very small scale process, which is happening
6 within the grid blocks of the larger scale.

7 The larger scale model is going to be a coarse
8 medium continuum that's volume averaged. It will see
9 things like gravity fingering and preferential flow.

10 So the point of looking at the Hele-Shaw model
11 was to visualize and look at the small scale processes and
12 then go back to the volume averaged simulation and see
13 what effect that might have.

14 MR. CAMPBELL: Okay. And have you done that or
15 is that anticipated?

16 MS. HUGHSON: Well, actually, that was -- then
17 when I went back and I looked at the volume averaged
18 model, then I would say, okay, how does this small scale
19 process, how is that going to affect what you see in the
20 volume averaged larger scale model.

21 And from that I came to the conclusion that if
22 you were to see this happen in the mountain or in a
23 thermal test, for example, it should happen very early on.

24 Then as the dry-out zone got bigger and the
25 refluxing zone magnitude got smaller, then you would have

1 to focus flow over a much larger area to actually see it
2 reach the opening.

3 MR. CAMPBELL: Is there any evidence of this
4 occurring in the heat drift test?

5 MS. HUGHSON: Well, that has to be a qualified
6 no. We have not seen any evidence of it in the drift
7 scale heater test, but then again you have to take into
8 account that the drift scale heater test is essentially a
9 ventilated test because the air can pass through the
10 thermal bulkhead.

11 And so there probably -- if it were to happen
12 there, it might not be seen because of this ventilation
13 effect.

14 MR. CAMPBELL: Thank you.

15 MR. HORNBERGER: But isn't there an ongoing
16 test with the sealed alcove?

17 MS. HUGHSON: The sealed alcove, yes, but
18 that's looking more at the ambient conditions. What we're
19 saying in terms of the cross-drift, and I'm glad you
20 brought that up, is that there's a planned test for the
21 cross-drift, the cross-drift thermal test.

22 And so in our IRSR, we came back and we said,
23 okay, you might have blown it on the first scale test with
24 this ventilation stuff. So think about this when you're
25 designing the cross-drift thermal test and don't let it

1 happen again.

2 MR. GARRICK: Good discussion.

3 MR. PABALAN: The Center and the NRC have also
4 been doing studies related to the chemistry and water in
5 the near field environment.

6 This is a key to understanding performance of
7 the engineered barriers. We've done a number of studies
8 to look at the temperature of water that enters into the
9 drift, as well as the water on the surfaces of the drip
10 shield and waste packages, and also look at the chemistry
11 of water inside the waste packages.

12 The last two bullets pertain to studies that we
13 have conducted based on the VA design and also the
14 information provided in the TSPAVA.

15 These studies range from fully coupled THC
16 processes to very quick calculations maybe on Excel
17 spreadsheet.

18 This slide presents the work that we have done
19 and continue to do. Actually, Lauren Browning did most of
20 these calculations to look at the chemistry of water
21 entering the drift. This is an ongoing study. It is
22 incomplete.

23 For me, it is hard to overstate the difficulty
24 in developing a coupled THC model. I've listed some of
25 the parameters that go into these kind of simulations.

ELLEN WALTERS, CSR
(817) 589-7648

1 We have to put in the water composition, the
2 water flux, the porosity, permeability, thermal
3 conductivity, et cetera, as well as thermodynamic and
4 kinetic data for the minerals that you are considering in
5 your assessment.

6 The approach that we have used is to calibrate
7 the THC model for the ambient conditions based on
8 available Yucca Mountain site data on groundwater
9 chemistry, mineralogy and hydrologic properties.

10 This allows us to have confidence in the
11 baseline conditions. I just showed some examples of a
12 comparison between the calculated calcium concentration as
13 a function of depth.

14 The yellow ones are the Yucca Mountain site
15 data. The red ones are the calculated values. On the
16 right figure will be the pH as a function of depth, again
17 comparing the Yucca Mountain site data with calculated
18 values.

19 So I think in order for us to have confidence
20 in predicting the evolution of the chemistry when you put
21 in heat, when you put in interactions with an engineered
22 barrier system, I think one has to have confidence in
23 these baseline conditions. You have to be able to
24 represent what's there right now.

25 The NRC and Center approach is in contrast with

ELLEN WALTERS, CSR
(817) 589-7648

1 what the DOE has done. The DOE has decided to calibrate
2 their simplified model. The model includes two minerals,
3 calcite and quartz, to represent Yucca Mountain. They
4 calibrated the model to a thermal perturbation event.
5 That is, data from the heater test.

6 My understanding is, based on discussions with
7 Lauren and with Debra, that this kind of modeling is not
8 able to calculate the ambient chemistry at Yucca Mountain.
9 So one has difficulty in having confidence in the
10 predictive capability of this kind of approach.

11 Like I said, this NRC and Center work is still
12 ongoing. What we intend to do is take the calculations
13 further from ambient conditions and then to apply heat to
14 see the evolution of water and to apply interactions with
15 the engineered barrier system to see what other kinds of
16 chemical changes occur as you do the fully coupled
17 simulations.

18 We've done a little bit of analysis for the
19 chemistry of water on the surface of the drip shield and
20 the waste package.

21 We have been doing and will continue to do
22 corrosion tests, and what we wanted to do is determine if
23 they have used some solutions that are bounding or
24 solutions that would be relevant to the Yucca Mountain
25 environment.

ELLEN WALTERS, CSR
(817) 589-7648

1 Our simplified analyses indicate, for example,
2 that evaporation of J-13 type solutions can concentrate
3 the water to 22,000 times its initial concentration.

4 Based on the initial flow and concentration of
5 J-13 well water, we calculated that one can have up to
6 0.14 mol/L of fluoride ion in the solution if it's
7 evaporated.

8 Now, this concentration, according to our
9 materials group, is within the window of susceptibility
10 for titanium. So I think one needs to consider these
11 kinds of processes when evaluating performance of the drip
12 shield.

13 In contrast, although DOE said they will be
14 conducting experiments with 20,000 times more concentrated
15 solutions than J-13 well water, there is no fluoride
16 present in their solutions.

17 Another point that was brought out yesterday is
18 the potential effect of trace metals like lead on the
19 performance of Alloy 22.

20 MR. LEVENSON: Excuse me a second. On the
21 previous one where you calculate a fluoride concentration
22 of .14 mol/L, that's a calculated number. Does that
23 assume that in a boiling down vapor reduction of 22,000,
24 you don't volatilize any fluoride at all?

25 MR. PABALAN: Yes.

1 MR. LEVENSON: That's what it sort of looks
2 like.

3 MR. PABALAN: Yes.

4 MR. LEVENSON: Is that a valid assumption?

5 MR. PABALAN: Under the pH conditions, probably
6 it is. The pH in these solutions would -- I don't have
7 the pH here, but it would probably be around 10 or so. HF
8 would be important under acidic conditions.

9 I don't know about the volatility of sodium
10 fluoride.

11 MR. LEVENSON: At 22,000 times boil down, there
12 are very few things that aren't volatile.

13 MR. PABALAN: The 22,000 times concentration
14 occurs at a temperature of 120 degrees.

15 MR. CAMPBELL: Bobby, is this the -- have you
16 done speciation --

17 MR. PABALAN: Yes.

18 MR. CAMPBELL: -- to establish that this is F-
19 minus?

20 MR. PABALAN: I believe so. Lietai Yang is the
21 one who did the calculations, but I would assume that it
22 does.

23 We have used the -- it's 9236. It's the
24 environmental simulation program systems, which can go to
25 very high concentrated solutions, considering also

1 speciation.

2 MR. WYMER: Did you take into account the
3 presence of calcium?

4 MR. PABALAN: Yes. Whatever calcium was
5 initially in the J-13 well water, we put in those
6 compositions and concentrations.

7 MR. WYMER: And allowed for precipitation?

8 MR. PABALAN: Yes. And as you evaporate, of
9 course, the boiling point goes up, so we have to take it
10 up to 120 degrees to bring it up to 22,000 concentration.

11 MR. CAMPBELL: Is this Upwell or Pitzer or
12 what?

13 MR. PABALAN: It's a mixed Meisner, Romney
14 approach.

15 [Multiple voices speaking at once.]

16 MR. PABALAN: With respect to the potential
17 effects of lead on the stress corrosion cracking of Alloy
18 22, we've done some preliminary calculations, allowing J-
19 13 well water to evaporate assuming 3.1 ppm of lead
20 initially based on the maximum concentration in solution
21 that we found from the Yucca Mountain site.

22 The pH evolved from about 8 at 25 degrees to
23 about 10 1/2 at 100 degrees centigrade, but what is
24 important in this calculation is that most of the lead at
25 that temperature after evaporation is really in the form

1 of lead carbonate species, and there's very low free lead
2 ion available.

3 So there's a question of what's the mechanism
4 for enhanced degradation of Alloy-22. If it's lead 2-plus
5 that is causing the enhancement, then perhaps we don't
6 need to be concerned about lead in the Yucca Mountain
7 environment.

8 We've done some analysis of potential
9 radiolysis effects on the chemistry of water in the drip
10 shield and waste package.

11 The DOE analysis, the test that they're doing,
12 assumed that the pH solutions would be greater than 2.7 of
13 water in contact with a drip shield and waste package.

14 There is a potential for radiolysis to cause
15 acidic condition. We've done some calculations showing
16 that a couple of hundred years or even after 10,000 years,
17 one can get very low pH's, even less than zero.

18 So we should note that there are a lot of
19 assumptions in these kinds of calculations, the water at
20 the surface, the closed system assumption for the
21 calculations. But the potential effect of radiolysis has
22 not been considered by the DOE in their analysis.

23 The same thing with the chemistry of water and
24 contact with... The DOE assumes in their abstraction of
25 the waste form degradation that the pH will be between 2.6

1 and 10.

2 There's a potential for radiolysis in this
3 particular case to cause enhanced dissolution of the waste
4 form of acid conditions. These calculations are for a
5 couple of hundred years after breach of the barrier. So
6 water in contact with the waste form could potentially be
7 acidic.

8 Now, we should note that these are preliminary
9 analysis. There's a potential for the pH to be buffered
10 by interactions with the other waste components and that
11 is something that we need to analyze with further
12 calculations.

13 With respect to --

14 MR. WYMER: Excuse me. If you get to these
15 very acidic conditions, then the question comes up again
16 of can you keep the fluoride in the water.

17 MR. PABALAN: Yes. That's something that we
18 needed to consider. These are separate analyses that we
19 conducted and we do need to consider all these
20 interactions.

21 MR. WYMER: And those are planned?

22 MR. PABALAN: Yes.

23 MR. LEVENSON: I have a question back on Graph
24 21 where you plotted the total dose after closure and the
25 pH of the film. Was that total integrated dose what was

1 used to calculate the radiolysis?

2 MR. PABALAN: I believe the --

3 MR. LEVENSON: Is that why they're plotted
4 together?

5 MR. PABALAN: I'm not sure.

6 MR. LEVENSON: If so, I don't understand it at
7 all because any drop of water coming down there is not
8 exposed to a thousand years worth of radiation.

9 MR. PABALAN: I think the only assumption that
10 I know is the nitric acid that forms on the surface
11 doesn't go away. So if there's water on the surface,
12 formation of nitric acid accumulates and it doesn't, you
13 know, it just stays there.

14 MR. HORNBERGER: The basic question is how do
15 the red crosses, the total dose after closure, relate to
16 the blue diamonds, the pH?

17 MR. PABALAN: I believe those red dots
18 represented dose used to calculate the generation of
19 nitric acid.

20 The Center and NRC have --

21 MR. LEVENSON: One second. This also has the
22 assumption in it that as this intermittently boils to
23 dryness, you don't lose any nitric acid?

24 MR. PABALAN: Yes.

25 MR. LEVENSON: That's not really a valid

1 assumption by a couple orders of magnitude.

2 MR. PABALAN: Yes. That probably is not a
3 valid assumption under the repository conditions.

4 MR. WYMER: It's just another reflection of the
5 complexity of the interaction of the coupled reactions
6 that are taking place here.

7 MR. PABALAN: Yes.

8 MR. WYMER: They really need to be accounted
9 for and it's very complex to incorporate it.

10 MR. PABALAN: Okay. With respect to, again,
11 the chemistry of water inside the waste package, a
12 potential concern is the effect of corrosion products on
13 the degradation of the glass.

14 All of our experiments indicate that when you
15 have ferrous chloride or ferric chloride in the system,
16 you have enhanced dissolution of the waste, of the high
17 level waste glass relative to dissolution in the ionized
18 water.

19 Granted that there is a similar effect when you
20 have only HCl present, suggesting that the pH is a main
21 factor, but still there is a difference that cannot be
22 accounted solely by the presence of HCl, but which we
23 believe is due to the presence of ferric cations.

24 MR. WYMER: You probably know that iron is used
25 as a means of measuring radiation dose. Have you taken

1 into account the changes in the ferrous/ferric ratio with
2 time as with radiation?

3 MR. PABALAN: No, we haven't. That is
4 something that --

5 MR. GARRICK: Is that an important thing?

6 MR. WYMER: It could be if you get into
7 discussions of reducing properties of ferrous ion with
8 respect to technetium.

9 MR. GARRICK: Oh, yeah. Yeah.

10 MR. EWING: Can I just ask a question
11 reflecting on your first statement here, "DOE
12 abstraction..." et cetera "...ignores potential
13 interactions with corrosion products."

14 By definition, an abstraction ignores a lot.
15 It's supposed to capture the main features. So do you
16 think that the things that follow that you list are really
17 major features in capturing glass corrosion? I mean, we
18 know every abstraction will suffer from this criticism.

19 MR. PABALAN: *Stradar, I think, wants to take
20 that question.

21 MR.* STRADAR: Nararsi Stradar* from the
22 Center. First of all, these are some preliminary
23 experimental results.

24 The purpose was really -- originally in our TPA
25 model, we had ignored glass as a thermal heater dose

1 because the inventory was small and we felt the
2 dissolution rate was also small enough that we could
3 ignore glass and focus on spent fuel.

4 The purpose of these studies was to really test
5 that hypothesis. If a corrosion product, for example, say
6 iron, is present due to the dissolution of components of
7 the waste package and then radiolysis, then we felt that
8 -- and if the glass dissolution rate is increased, then
9 perhaps we should also consider glass dissolution models
10 in our TPA code.

11 So right now, where we are is that while we are
12 criticizing DOE for not including the corrosion products,
13 we also have to do some sensitivity studies using our TPA
14 code to see whether this increased dissolution rate of the
15 glass contributes significantly to dose. If it doesn't,
16 then it's never mind.

17 MR. EWING: But the TPA presently doesn't
18 include the glass?

19 MR. *STRADER: Right. It doesn't.

20 MR. PABALAN: There's also a concern about the
21 assumption of a J-13 well water composition. In DOE's
22 analysis of waste form degradation, they assume that J-13
23 composition enters into the waste package and that is what
24 interacts with the waste package components.

25 We have initiated some experiments to try and

1 look at the chemistry of water that drips into the waste
2 package. This diagram is just a cartoon of the
3 experimental apparatus that we're using where we simulate
4 some sort of a crevice in the Alloy 22 or at this initial
5 stage, the 316L stainless steel.

6 And we're going to look at the chemistry of
7 water that drips into the system that could interact with
8 waste package components at some point.

9 The main question that we have is what is what
10 is the pH of water that drips into the waste package? Is
11 it really just J-13?

12 We expect in a crevice corrosion to get acidic
13 pH and that's what we're trying to look at with this kind
14 of experiment.

15 MR. WYMER: In the previous viewgraph you had
16 something called "internal components."

17 MR. PABALAN: Yes. The initial experiments --
18 there are two halves to this experimental system.
19 Initially, we're just going to let water flow through this
20 crevice so we can measure the pH and measure the
21 composition as the 316L degrades.

22 The second part of the experiment is we will
23 let this fluid in a flow-through type of experiment
24 interact with, for example, glass or some other waste form
25 simulant or waste package -- waste component.

1 MR. WYMER: What specific things do you have in
2 mind to stick in there first?

3 MR. PABALAN: I believe glass is what is
4 planned initially.

5 MR. WYMER: Iron, sooner or later?

6 MR. PABALAN: Yeah.

7 MR. WYMER: Okay.

8 MR. PABALAN: The VA design includes an
9 estimated 179 kilometers of emplacement drifts in the form
10 of concrete inverts and linings.

11 We were concerned at that time about the
12 potential interaction of the alkaline fluids resulting
13 from interaction with cement.

14 We did some coupled -- we did some THC -- no,
15 hydrological chemical simulations to look at the potential
16 interaction of the alkaline plume with the tuff host rock.

17 Our results indicate that you do get porosity
18 reduction of the tuff matrix along the boundary between
19 the concrete and the tuff that could isolate the matrix
20 from fracture pore water, which could have an effect on
21 transport and diffusion processes.

22 This kind of simulation did not consider the
23 temperature effect, however. We couldn't do a THC type of
24 simulation because we did not have the temperature
25 dependence information.

1 So what we did as a next step is to do a number
2 of experiments, actually done at the University of
3 Aberdeen, to look at the temperature effects on the cement
4 chemistry and cement properties.

5 Experiments were done by steam curing of
6 Portland cement paste at 130 and 200 degrees Centigrade to
7 look at the evolution of the minerals, of the cement
8 minerals, initially CSH, calcium silicate hydrate gels as
9 a function of time.

10 The figure is little bit busy but the bottom
11 line coming out of this kind of study is that
12 recrystallization of the initially amorphous CSH phases
13 results in lower pH.

14 So when you have Portland present, the main
15 component present in cement, you're going to have very
16 alkaline pH of 12.4 or something like that, but as you
17 recrystallize the amorphous CSH, then it goes down to
18 lower pH's.

19 The thing that we take away from this is maybe
20 in a heated repository one may not necessarily be
21 concerned about the pH effects of the concrete lining.

22 MR. WYMER: Here you've got the pH going way up
23 and another example of the radiolysis the pH is going way
24 down. So there must be some sort of a null point there.

25 MR. PABALAN: Yeah.

1 MR. LEVENSON: That's why you couple them.

2 MR. PABALAN: The last study that we have
3 initiated or we conducted actually relates to the TSPA-VA
4 hypothesis that some of the radionuclides will be uptaken
5 by secondary uranyl phases.

6 We wanted to be able to test the DOE hypothesis
7 with respect to the importance of this process. We
8 conducted some synthesis of uranophane, which we were
9 planning to use in our experiments, but because the TSPA-
10 SR will not take credit anymore for second mineral phase
11 formation, we have relegated this --

12 MR. WYMER: What did you just say?

13 MR. PABALAN: I'm sorry?

14 MR. WYMER: You just said what? The TSPA will
15 what?

16 MR. PABALAN: The site recommendation TSPA will
17 not use the uptake of radionuclides by second phases.
18 They will not take credit for it.

19 MR. GARRICK: No retardation.

20 MR. PABALAN: No retardation.

21 MR. GARRICK: From secondary products. It's
22 amazing.

23 MR. PABALAN: They believe there's significant
24 -- there's a lot of uncertainty with respect to the
25 importance of that process, of that mechanism.

1 So they have decided not to take credit for
2 retardation by secondary phases.

3 MR. WYMER: "They" is DOE?

4 MR. PABALAN: DOE, yes, which means this study
5 is not as important anymore from the NRC perspective and
6 this experiment right now is not being pursued by the NRC.

7 MR. HORNBERGER: Do you know if DOE is pursuing
8 such experiments?

9 MR. PABALAN: I believe Argon National
10 Laboratory is still doing some of those experiments.

11 MR. LEVENSON: Their not taking credit for it
12 does not change the uncertainty. It just puts all of the
13 uncertainty on the safe side.

14 MR. PABALAN: Yes.

15 MR. HORNBERGER: The problem that I see, and we
16 had commented on this, the worry that I have is that a
17 comment like that without having any data -- I mean, I
18 would like to see some of these experiments done to either
19 confirm or refute the fact that these secondary minerals
20 might be a truly significant mechanism for immobilizing
21 certain nuclides, neptunium in particular.

22 And that's independent of whether it's in the
23 performance assessment or not. I'd just like to know
24 whether the process occurs.

25 MR. GARRICK: Have a major impact on the peak

1 dose.

2 MR. HORNBERGER: It could.

3 MR. GARRICK: Could have.

4 MR. HORNBERGER: On the other hand, if all we
5 have are these statements that, oh, well, we're not taking
6 credit for this so we're being terribly conservative, we
7 don't really know how conservative.

8 MR. LEVENSON: I think there's a philosophical
9 point, George, I agree with, and that is while NRC's job
10 is primarily to review what DOE does, in order to decide
11 whether the health and safety of the public is really
12 being protected, we need to know where the conservatisms
13 are, as well as what they're doing.

14 MR. GARRICK: Just pushing that a little
15 further, has DOE presented any rationale for deciding not
16 to --

17 MR. PABALAN: Yes. In the AMR and waste form
18 degradation and PMR and waste form degradation, they do
19 say, well, there's a lot of uncertainty with respect to
20 how much radionuclide would be uptaken by secondary
21 phases.

22 They cannot provide a high degree of confidence
23 in the results to allow them to take credit for it.

24 MR. GARRICK: Well, as an old risk analyst,
25 uncertainty, the existence of uncertainty is not a reason

1 for eliminating something. On the contrary, it's a risk
2 for including something. But go ahead.

3 MR. McCARTIN: If I could, from the perspective
4 of the program though, with a certain fixed budget with
5 limited resources, we have to prioritize what we want to
6 go after, and we are driven to a certain extent by where
7 DOE is headed and weaknesses that we need to explore.

8 This is one of those cases while it can be an
9 important process to reduce releases, looking on it just
10 by ourselves doesn't make sense with other things out
11 there like as you've heard discussed previously.
12 Corrosion products, et cetera, are things more of
13 interest.

14 MR. GARRICK: Right.

15 MR. LEVENSON: But Tim, our charter is
16 different than yours. You have to live in the real world
17 and can only do what your funds are.

18 If we see something we think is important and
19 is not funded, it behooves us to point it out.

20 MR. McCARTIN: Agreed.

21 MR. EWING: Comment on these. I want to
22 reinforce the statement that this could be very important.
23 DOE may not take credit for it this year but next year it
24 may be on the table, and these experiments are not easy.
25 You can't turn them on and off. They take years to get

1 going handling radioactive materials.

2 The other point, work is being done around the
3 country in other laboratories and there's no reason why we
4 can't collaborate with people and take advantage of their
5 funded programs to get at least some idea whether this is
6 important or not.

7 And I'll bet you a lot it's potentially very
8 important, particular for neptunium.

9 MR. McCARTIN: I won't disagree. However, I
10 will say that if DOE is going to take credit for
11 something, the burden of proof is on the Department of
12 Energy. Our results are primarily confirmatory, research,
13 tests, et cetera.

14 I do agree with you but ultimately DOE will
15 have to defend.

16 MR. GARRICK: I think we got the message.

17 MR. PABALAN: So to summarize, it's clear that
18 coupled processes could affect repository performance,
19 especially in the near field environment.

20 Now, these effects, of course, are included
21 indirectly and only indirectly in performance assessments,
22 such that the NRC and the Center will need to continue to
23 evaluate couplings of processes at a process level so that
24 we can test the bounding assumptions, for example, of the
25 DOE, or the ranges of parameters that they use in their

1 TSPA calculations.

2 The NRC and the Center, these evaluation of
3 coupled processes is being done in a risk-informed
4 performance-based manner. We need to continue doing these
5 analysis and studies, but we have to focus on those that
6 are important to performance.

7 Thank you.

8 Lietai, they have a question with respect to
9 your calculations of radiolysis effects. Two things, the
10 assumption of no evaporation occurs at the surface; is
11 that correct?

12 Lietai Yang from the Center.

13 MR. YANG: Lietai Yang from the Center. I do
14 not quite understand the question.

15 MR. PABALAN: The question with respect to
16 this, I believe, and also to the next figure, the
17 calculations are for nitric acid concentration and
18 generation of acidic conditions.

19 There was an assumption of no evaporation of
20 water and no loss of nitric acid due to the heat.

21 MR. YANG: The assumption is there is no loss
22 of -- we assume that all the produced nitric acid will
23 stay there, and we do not know any kind of mechanism that
24 will react with the produced nitric acid so we just assume
25 it keeps accumulating.

1 This assumption may be wrong but at the present
2 time we have not seen any DOE calculations, so this is our
3 preliminary approach.

4 MR. LEVENSON: Some of us that spent some years
5 recovering nitric acid by steam distillation will tell you
6 that it is very volatile, but I think there's a more basic
7 point to be made.

8 The last bullet on your last slide, the use of
9 pessimistic or bounding or extreme conditions is really
10 not consistent with risk-informed performance-based
11 manner.

12 You can't say you're doing it in a risk-
13 informed performance-based manner when you take extreme
14 assumptions.

15 You really, unless you're doing your best
16 estimate and trying to identify the uncertainties that go
17 with it, you're really not doing it risk-informed.

18 MR. PABALAN: I'm not going to argue with him.

19 The other question, I believe, is with respect
20 to your figure, Lietai, on the dose that you use to
21 calculate in the first figure for gamma radiolysis, did
22 you assume -- those red dots, symbols, those are the dose
23 rates that you used to calculate the nitric acid
24 generation?

25 MR. YANG: This is for drip shield waste

1 package?

2 MR. PABALAN: Yes.

3 MR. YANG: Yeah, we derived at those because we
4 have not seen the publication of dose for the EPA to
5 define, so in '98, '97, DOE published a report calculating
6 dose for...design. That calculation only was from zero
7 years after emplacement to 150 years emplacement.

8 So we calculated that calculation. Of course,
9 this is also preliminary because we have no other means to
10 do the calculation.

11 MR. LEVENSON: Well, the question was slightly
12 different. This is a continuous dripping in of water and
13 the question was, it looks from the curve like a drop of
14 water that dripped in in year 1000, you attributed for
15 radiolysis purposes to all of the exposure or dose for the
16 previous thousand years.

17 This looks like an integrated dose curve and
18 yet the drops of water are exposed to the radiolysis dose
19 of only the residence time, not the integral.

20 MR. YANG: Yeah. This nitric acid production
21 predominantly in the air space. So that interaction
22 of...and the nitrogen in the air. So we calculate the
23 residence time. My understanding is to calculate the
24 residence time of nitrogen in the air space, not the water
25 dripping down.

1 MR. ESH: Dave Esh. That residence time would
2 be even shorter because the air circulates pretty rapidly
3 in the drifts, more so than the water.

4 MR. YANG: Okay. Our calculation is we assume
5 that the closure is at 50 years. After the closure, we
6 assume no circulation. Of course, this is also
7 preliminary.

8 MR. McCARTIN: I'd just like to offer one
9 thought on the risk-informed part. We certainly agree for
10 the risk-informed approach, but please appreciate that
11 what you get is a snapshot of where we are today.

12 And all these calculations are very much
13 iterative and we're starting down this path and sometimes
14 the early calculations tend to make some more conservative
15 assumptions that we refine as time goes on. But it really
16 is a snapshot and it's not the final end point.

17 MR. LEVENSON: I think we appreciate that, Tim.
18 The concern is sometimes, particularly on very limited
19 programs, you don't have time to go back and very early
20 assumptions get embedded, unfortunately.

21 MR. WYMER: Is that the end of the --

22 MR. PABALAN: Yes.

23 MR. WYMER: Any more comments? I want to make
24 a few wrap-up comments.

25 MR. EWING: I have one comment going back to

1 the chemistry of the water inside the waste package. I'm
2 surprised to learn that glass dissolution isn't part of
3 that consideration because with commingled disposal of the
4 fuel and the glass, one of the principal chemical
5 components is glass. So it's hard to imagine how you
6 would successfully model what happens inside the waste
7 package without glass corrosion.

8 On top of that, if I understand correctly, your
9 approach will be to see if that has any effect on the
10 final dose and run through the calculation. But I'd
11 simply point out that in terms of dose, the total activity
12 in the glass is only 5 percent of the total activity in
13 the repository.

14 So one difficulty is when you run that
15 calculation, the corrosion of the spent fuel dominates
16 that final dose calculation and it really doesn't give you
17 a good idea of how important glass is to what's going on
18 inside the waste package.

19 So this may be an example where that final
20 calculation is not a useful discriminator of what you need
21 to do to develop the models.

22 MR. PABALAN: Let me just make one
23 clarification. The DOE does indeed consider the
24 degradation of the glass in their calculations of the
25 chemistry inside a waste package.

ELLEN WALTERS, CSR
(817)589-7648

1 I don't think we had that at the Center and at
2 the NRC, we have not done that kind of calculation, but we
3 do intend to do that.

4 With respect to the contribution of glass to
5 the total dose and discriminating the effect of glass on
6 total dose, I agree with you. It's hard to discern, just
7 because the spent fuel has such a big inventory, what the
8 contribution of glass would be.

9 MR. McCARTIN: Probably one aspect, I believe
10 the technetium inventory in glass is fairly high. It's a
11 non-trivial amount.

12 For the other radionuclides, yes, but it does
13 have a substantial amount.

14 MR. LEVENSON: I think there's a more important
15 issue related to glass and that is the present plans are
16 to dispose of many, many tons of plutonium by the can-in-
17 can process where plutonium wafers will be inside the
18 glass. It's not at all clear that that's an insignificant
19 contributor.

20 MR. EWING: If it becomes that 50 metric tons,
21 to put it in perspective, the total inventory is around
22 600, 650 metric tons.

23 MR. LEVENSON: Yeah, but this is concentrated
24 by many, many orders of magnitude so that the number of
25 canisters that need to fail is much, much less. It isn't

1 at all clear that it's not part of the risk.

2 MR. WYMER: With respect to technetium, once
3 you breach the canister, the waste package and get into
4 the fuel, it's not at all clear either that the technetium
5 will be coming out as a... It's fairly certain that a
6 significant fraction, maybe a third in some cases, of the
7 technetium will be metallic and a finely dispersed
8 technetium metal.

9 This is observed many times in the fuel
10 reprocessing business, so that's another. So there are a
11 number of things that are subtle, maybe second order, but
12 they relate to important products. They really need to
13 have some attention paid since those are the dose
14 contributors.

15 I wanted to make a few comments. One, it's
16 apparent, I think, that this whole business of coupled
17 processes is extremely complex, almost impossible to model
18 completely, first because the phenomena aren't even
19 understood, and if they were, the data required to
20 elucidate the phenomena are not available, either kinetic
21 or thermodynamic.

22 And finally, the uncertainties in the mountain
23 itself and the type and rates of water coming in are
24 uncertain.

25 And another point is, and this gets into

ELLEN WALTERS, CSR
(817) 589-7648

1 something that was discussed earlier, you're always
2 confronted with the problem, it seems, of what is needed
3 now -- this gets at Tim's point -- to really evaluate the
4 license application as we presently understand what will
5 come in, and what might be needed in the future.

6 For example, if it turns out to the
7 satisfaction either of the technical community or of the
8 public, if you can't really guarantee that the C-22 will
9 stand up, then what's your fallback, what's DOE's fallback
10 position, what will they resort to.

11 One of the few areas they have yet to fall back
12 on are the chemistry-related areas, things like secondary
13 phase formation, incorporation of neptunium and others in
14 the films.

15 So there's a balance. It's been pointed out
16 that there's not enough time after you discover that
17 things have changed to get the data, do the experiments,
18 do the calculations to address the new approaches.

19 This either means that DOE has got to run out
20 farther in the future with respect to when they put in
21 their license application or that the NRC has to be able
22 to evaluate it when DOE does short of shove it into the
23 breach.

24 So there is a balance that's required. That's
25 a nice matter of judgment to decide what might be these

1 important features that might be brought into the picture
2 provided the picture changes.

3 I realize that's a tough question, but it's one
4 that we really have to pay some attention to in trying to
5 decide what are the key things that might be done if the
6 C-22 can't be relied upon to the extent that it currently
7 is being relied upon, either for technical or for
8 political or public relations reasons.

9 I asked the question yesterday of the DOE
10 representative, "Do you consider in your decision making
11 and what you decide you can and can't do the public
12 input?" And the answer was, " Yes." And I think that
13 they must incorporate that into their thinking. So that's
14 one thing I wanted to say.

15 Another is that the situation is so complex
16 that in fact, you can't really do it. You can't solve the
17 coupled chemistry problems analytically. There are just
18 too many.

19 So it's extremely important, in my opinion
20 anyway, to carefully design experiments that come as close
21 as you can possibly make them to simulate what will happen
22 in the repository.

23 That's one way to sort of get a look at what
24 might happen in an overall chemical sense. You couple all
25 the processes experimentally instead of analytically and

ELLEN WALTERS, CSR
(817)589-7648

1 you try to find out what the result is.

2 That's the reason I thought that your figure on
3 page 24 was particularly important because that comes as
4 close as anything I've seen described as trying to get an
5 integrated coupled look at everything that might happen in
6 a repository.

7 I would urge you to think as carefully as you
8 can about designing experiments. Grasp all of the
9 couplings in reasonable rational chunks as nearly as you
10 can to deal with these things experimentally that you
11 can't hope to deal with analytically.

12 And I guess that's probably my sermon today.
13 Any other observations or comments? Rod, what do you want
14 to say about this?

15 MR. EWING: Your sermon was much appreciated.

16 MR. WYMER: Okay. Very good. I think you're
17 doing a good job here and I think you've got a lot of work
18 yet to do.

19 MR. GARRICK: Before we break up, I want to do
20 a couple of things just as closing. When we came in here
21 two-and-a-half days ago, we came in with a strong desire
22 to learn more about the high level waste program, the
23 tools that are being employed, the guidance that's being
24 provided and the capability.

25 And while it's been a very congested agenda

1 with tremendous amounts of material thrown at us, I think
2 the Committee in general is very pleased with the job that
3 was done in terms of responding to the ground rules for
4 the meeting.

5 In that regard, we certainly want to thank all
6 the speakers. This is a tough duty. The presentations
7 were excellent and the frustration the Committee always
8 has in this kind of engagement is having an adequate
9 amount of time for exchange and discussion and we always
10 work on that problem.

11 The 50 percent rule doesn't always work where
12 we ask the presenters to allow us about half the time for
13 discussion, but we're going to keep pressing for something
14 like that. But the speakers did an outstanding job and we
15 want to thank them.

16 We also want to thank the Center staff and
17 management, as well as the NRC. This meeting was handled
18 extremely well.

19 The cookies were excellent. The weather was
20 good. The transportation was good, although my driver got
21 lost a couple of times.

22 But we would like to especially thank Wes
23 Patrick and Budhi Sagar*. Also the people that handled
24 the audio-video, Theron Brown in Washington, and Melissa
25 Van Hecke* here, because it's a very difficult thing to do

ELLEN WALTERS, CSR
(817) 589-7648

1 and I think they did a commendable job.

2 And we would like to than everybody that was in
3 attendance. The interest they showed, the discussions
4 that they added, and the break corridor interactions that
5 took place were all very constructive.

6 MR. WYMER: I think we nearly killed our
7 recorder yesterday.

8 MR. GARRICK: Yes. So unless there's another
9 comment to be made by anybody, if anybody has a question,
10 I'm going to adjourn this part of the formal meeting and
11 allow us to prepare for our tour.

12 Adjourned.

13 [Meeting adjourned.]

14

15

16

17

18

19

20

21

22

23

24

25

CERTIFICATION OF TRANSCRIPT

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25

I, Ellen Walters, hereby certify that this is the transcript of the proceedings held before the U.S. Nuclear Regulatory Commission in the matter of the 123RD MEETING OF THE ADVISORY COMMITTEE ON NUCLEAR WASTE, at SAN ANTONIO, TEXAS, on November 29, 2000, and that this is a full and correct transcript of the proceedings.

Ellen Walters, CSR

My Commission Expires: 12/31/01

P.O. Box 14361

Fort Worth, Texas 76117

(817) 589-7648

ELLEN WALTERS, CSR
(817) 589-7648