

UNITED STATES  
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WINTER BOARD MEETING

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Amargosa Valley, Nevada

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1 Lake Playa that we visited. Several of us have done this  
2 several times, and the whole Board was here earlier last  
3 year. We've looked at the Death Valley area, some of us.  
4 Some of us have seen the Ash Meadows discharge area. And  
5 after having visited these areas, you can't help but get a  
6 totally different impression of the desert. There's a lot of  
7 water coming out in the desert. It's a totally different  
8 perception that you get if you stand on the crest of Yucca  
9 Mountain and get the feeling that this is really a dry  
10 desert.

11           We get another view when we go into Brown's Room in  
12 Devil's Hole. It's a window into a paleoclimate record,  
13 which is outstanding and very useful to the program. And  
14 yesterday, Russ Dyer gave us four performance attributes of a  
15 repository. One was limited water contacting waste packages  
16 and design containment, the waste package lifetime question,  
17 slow rate of radionuclide release, in part due to engineered  
18 barriers, and ultimately, the concentration of reduction of  
19 radionuclides during transport in the unsaturated and  
20 saturated zone. Well, that's today's topic, the saturated  
21 zone, and we'll focus on efforts to understand the local and  
22 regional hydrology of the saturated zone.

23           In time, some radionuclides inevitably will reach  
24 the water table and be transported to accessible environment,  
25 and so the question is in the early days when we thought the

1 mountain was dry, you wouldn't have to put any attention on  
2 regional ground-water flow, but today, we know that's an  
3 important part of the story. There's a higher flux rate in  
4 the mountain at present, and there was higher flux rates in  
5 the past, and surely there will be again in the future with  
6 climate change.

7           We know there are some fast flow paths that exist  
8 within the unsaturated zone, and surely there must be similar  
9 fast flow paths within the regional ground-water flow system.  
10 So one has to then understand the transport and flow of  
11 water in the saturated zone. There's certain questions that  
12 have to be answered. What is the ground-water path like to  
13 the accessible environment? That may be in part set by rules  
14 of the EPA, but on the other hand, ultimately water is going  
15 to come out somewhere.

16           What are the expected ground-water travel times  
17 within the ground-water flow channels that might receive  
18 radionuclides that are released from the repository? And  
19 what are the respected retardation mechanisms that will slow  
20 down or eliminate some radionuclides that as a result will  
21 never get to the discharge areas? And how much mixing and  
22 dilution can we expect during transport within regional  
23 ground-water flow field, and how much mixing and dilution can  
24 we expect at points of possible future withdrawal of ground-  
25 water, either from small capacity or high capacity wells?

1 And how might future climate change change these conditions  
2 in terms of flow path rate, velocities of ground-water flow,  
3 volumes of flow, and points of discharge?

4           Now, several targets are available for calibrating  
5 and validating models, and we'll hear some of these today.  
6 But, one, you could use point hydraulic head data in the  
7 regional flow field, or patterns of the water table  
8 configuration on a more regional scale. Or we could look at  
9 the spatial distribution of hydraulic conductivity  
10 distribution in rocks and alluvium. And then there's a  
11 spatial and temporal variation of recharge throughout the  
12 whole flow field, as well as the discharge areas in the flow  
13 field. And transport prediction, on the other hand, is even  
14 more difficult because we have the question of understanding  
15 the velocity of ground-water flow, and then eventually  
16 transport processes are tied to that. But will plumes that  
17 inevitably develop under the mountain broaden and spread and  
18 result in good mixing and dilution, or will it be really a  
19 narrow track or focused flow where we really can't count on  
20 much dilution?

21           And will colloids be a significant transport  
22 mechanism in the saturated zone? And we heard yesterday  
23 there will be efforts looking at the unsaturated zone, but  
24 both saturated and unsaturated zone transport is important.  
25 And for models, what are the boundary conditions that we have

1 to deal with? Do we really need to know what the steep  
2 hydraulic gradient is caused by in the northwest portion of  
3 Yucca Mountain, and do we need to put major faults in the  
4 flow field in the pathway analysis? How uncertain are the  
5 head distribution and conductivity distribution within the  
6 regional flow field? And does it make any difference at this  
7 stage in the analysis.

8           And so can we reduce uncertainty in our  
9 understanding of the flow field and transport models in the  
10 short time that remains between now and recommendation of a  
11 site or for LA? But if we don't understand it, what does  
12 that do in terms of slowing down the whole process of getting  
13 a license that finally will work?

14           Stay tuned to all of today, and we will learn all  
15 about these questions, we hope. We expect answers on all of  
16 them, and if not, then we need to know what additional  
17 research needs to be done in a timely manner to support a  
18 decision to go forward with Yucca Mountain and to deal with  
19 the question of the license application.

20           Today, the speakers are going to be varied, and  
21 we'll have an overview of a saturated zone program and it's  
22 objectives, we'll look at the three dimensional ground-water  
23 flow model for the Death Valley Basin, which is a very large  
24 study area with discharge areas throughout the window beyond  
25 you there. We'll look at significant hydrochemical domains

1 in the saturated zone at Yucca Mountain. Surely there are  
2 fingerprints that show something of the history of the water,  
3 the age of the water. What do we know about that? And we  
4 have to model for major ion chemistry in saturated zone  
5 waters along flow lines through Yucca Mountain.

6           There's tracer tests at the C-Well Complex. You'll  
7 learn more about that, and we're going to have a three  
8 dimensional finite- element model discussion for saturated  
9 zone in the Yucca Mountain area, which is a site scale model,  
10 current status of the saturated zone flow and transport  
11 model. We discussed State of Nevada studies for the  
12 saturated zone, Nye County proposed saturated zone work, some  
13 questions and answers at noon, if some of you have to leave.  
14 We hope we'll have time for discussion then.

15           And then we have the whole elicitation process, the  
16 expert panel process, and that will occur later in the  
17 afternoon. We have saturated zone flow and transport  
18 conceptual model and parameter issues that will be discussed,  
19 and late in the day, our expert opinions on the part of two  
20 people who served on these panels. And then finally total  
21 system performance and what to do with the saturated zone in  
22 that regard, and thermal testing updates, and finally  
23 questions late in the day, a very full agenda.

24           The hope is not to cut off discussion if it seems  
25 very active and vital, but at the same time, to try to cover

1 all of these speakers, we'll have to kind of do this in a  
2 business-like manner.

3           So the first presenter today will be on an overview  
4 of the saturated zone program and its objectives from William  
5 Boyle, and we heard from him yesterday, so I'll not go  
6 further with introductions.

7           Thank you.

8           BOYLE: Good morning. Thank you for being here.

9           I'm here to present an overview of the project's  
10 work on the saturated zone. Some of the talks this morning  
11 will be by others, Nye County and the State.

12           For those of you who are not a scientist, I'll  
13 provide a little background on the saturated zone, for those  
14 of you in the audience. The soils and rocks are saturated if  
15 every hole or crack in them is full of water. In contrast,  
16 usually the overlying rocks, if there's any air there,  
17 they're called unsaturated.

18           At Yucca Mountain, the saturated zone is very deep.  
19 Here in Amargosa Valley, it's not. For those of you who  
20 have never been over to Ash Meadows, I really recommend it.  
21 If you see the saturated zone, it's quite a pretty area, too.

22           In contrast to Russ Dyer yesterday, I will talk to  
23 all my slides. I really don't have that many.

24           Saturated Program Objectives. This slide largely  
25 talks to what are the objectives. What is it the studies

1 want to get? What's the ultimate goal? We want to  
2 understand the saturated flow system in the vicinity of Yucca  
3 Mountain. How does the water move around? More  
4 specifically, provide ground-water flow fields. That's, in  
5 layman's term, how much water is moving, where it's moving,  
6 when is it moving.

7           The first two bullets deal mainly just with flow of  
8 water as a material. The last bullet is also concerned with  
9 the saturated zone studies, and it's more chemical in nature  
10 for the most part. It's what happens to materials in the  
11 water. Are they diluted or do they precipitate, or are other  
12 materials dissolved? That was the what of the saturated  
13 zone.

14           You can think of this slide as, well, who's going  
15 to use the results. And in short, the entire project over  
16 time. The results are used in the viability assessment.  
17 They're used in license application and ultimately if the  
18 repository is built, in performance confirmation.

19           This slide is power to the data collector, and  
20 you'll hear a little bit about all of these things from the  
21 other speakers today. But how the data are collected;  
22 there's water-level monitoring, aquifer testing, pump  
23 testing, if you will, how much water can be pumped out of the  
24 saturated zone over a given amount of time. Samples are  
25 obtained for chemical studies, and then as with any data

1 collection activity, there's always associated modeling.

2           This is a summary you could look at the speakers to  
3 follow, at least from the project speakers; these are the  
4 topics that they're going to discuss today. You can read  
5 them as well as I can, and I'm just here to set the stage for  
6 the speaker.

7           In the agenda, there was no time for questions for  
8 me, which is okay. I don't think I'm over schedule yet, so  
9 there's something I'd like to bring up from last night. Many  
10 people here this morning weren't here last night, and a  
11 question came up about study plans and the site  
12 characterization plan, but it was specifically related to  
13 saturated zone studies, and it was a question of essentially  
14 why aren't we doing what was in the study plans or the SCP,  
15 and how do we explain why we're not.

16           And Russ Dyer addressed it from a project control  
17 point of view, how we take care of planning our project in  
18 the absence of the study plans. Chairman Cohon stated that  
19 it was a good question, then answered it himself and gave a  
20 very realistic answer, that the project needs to focus on  
21 certain activities and make tough choices and maybe some  
22 things won't be done that people once thought would be done.

23           Now, it is a very good question, as the Chairman  
24 pointed out. It's also a question that the Department has to  
25 answer in the license application. There's a specific

1 requirement in Part 60 that we describe what was in the study  
2 plan, what we actually did, and why we did it differently.  
3 And we're not waiting for the license application to explain  
4 this. As part of our twice yearly progress reports, there is  
5 an appendix in the back, Appendix A, that explains what was  
6 originally planned and what is being done and the status  
7 thereof.

8           One final remark on the question; perhaps I'm too  
9 sensitive, but as people ask why aren't you doing what was in  
10 the SCP or the study plans, there may be an implication that  
11 the SCP and the study plans were somehow right and what we  
12 are doing now is wrong. I would put forth that there is no  
13 right answer in site characterization. There is no manual to  
14 go to to look up that says you need four bore holes, not  
15 three, not five.

16           So as people ask this question, I hope they do  
17 realize that it's a tough issue to deal with; that there is  
18 no cut and dried, right and wrong answer.

19           Now, having said that, are there any questions?

20           (No response.)

21           PARIZEK: The Board is quiet. Staff? I guess we'll  
22 just get at you later in the day I'm sure one way or another.

23           The next presenter is Frank D'Agnese, who's going  
24 to report on regional three dimensional ground-water flow  
25 model of the Death Valley Basin. And we've got to make a

1 distinction between the regional flow model and the site  
2 scale model, and that will become clear as we go along today.

3           Frank has been on the regional ground-water flow  
4 model study for quite a long time. He's had experience in  
5 the desert area sampling paleospring deposits, and we're  
6 happy to have you make your presentation.

7           D'AGNESE: Thank you. I was originally asked to give an  
8 overview of the region, and then they told me I have 15  
9 minutes to do that.

10           What I'm going to do I think is to spend about 15  
11 minutes here kind of giving you an overview of the goals, the  
12 objectives and some of the basic conclusions of the regional  
13 modeling studies. For those who are interested in detail,  
14 the report for this study has just gotten off the presses,  
15 published as USGS WRI 96-4300, and that is available.

16           Now, this overhead here shows the outline of the  
17 Death Valley Basin, and in general, it includes about 80,000  
18 square kilometers. It's a pretty large area that straddles  
19 Southern Nevada and Southeastern California, and Yucca  
20 Mountain is located approximately in the north-central part  
21 of that area. Death Valley is the ultimate discharge area of  
22 that flow system.

23           Dominantly, this basin is closed, and that means  
24 that we don't have any ground-water fluxing into that basin,  
25 except for maybe a little bit of water that enters the basin

1 from what is known as the White River or Pahranaget Lakes  
2 area. So in our effort to characterize the regional flow  
3 system, this is the basin that we concentrated on.

4           And our objectives of our modeling exercise were to  
5 define subregional and local boundaries, major regional flow  
6 paths, regional recharge and discharge locations, as well as  
7 rates to help define flux through the system.

8           We're studying the effects of this very large  
9 carbonate aquifer which controls flow throughout the entire  
10 region. And then once we've done that, to use the model to  
11 assess the effects of climate change, water-use changes and  
12 structural changes to the system.

13           Our approach was to characterize the hydrogeology  
14 of the region and discretize this hydrogeology down into  
15 small packets that we could then simulate ground-water flow  
16 through. By calibrating our regional model, we were testing  
17 various conceptual models of the flow system. Once we had  
18 done that, we did a series of evaluation steps or validation  
19 steps on our model. From that point on, we can develop  
20 either recommendations for improving the model, or then use  
21 the model for some scenario testing. And I'll give you an  
22 example of one of those.

23           To characterize the hydrogeology, the first step  
24 was to develop a whole series of geologic cross-sections  
25 throughout the region, and we see here a whole slew of cross-

1 sections developed by several geologists that describe the  
2 distribution of the hydrogeologic units within the region.

3           We took this information and we took those geologic  
4 cross-sections and we placed them into a digital environment,  
5 the computer, so that these cross-sections could be hanging  
6 in their three dimensional space. And here, we start to see  
7 the distribution of these very complex units in 3-D space.  
8 We took that information and correlated between those cross-  
9 sections to develop a solid three dimensional representation  
10 of a one conceptual model of the hydrogeology for the Death  
11 Valley Region.

12           And so what we see here is this very large three  
13 degree by three degree area of a digital representation of  
14 the hydrogeology. Las Vegas would be located here. This is  
15 the Spring Mountains. Death Valley would be located here,  
16 Amargosa Valley, Yucca Mountain to the top there. And so  
17 what you see in these little squares here is just basically  
18 the resolution of our digital model.

19           Along with geology, we characterized things like  
20 potential recharge areas. These are the recharge areas. The  
21 major recharge area for the flow system would be the Spring  
22 Mountains out here to the east, the Sheep Range, Pahute Mesa  
23 and Delta Range, and even areas like Timber Mountain and  
24 Shoshone Mountain to the north.

25           In addition to recharge, we characterized major

1 discharge areas, not only where discharge is occurring, but  
2 also to quantify the amount of water coming out of these  
3 discharge areas, because this flux is going to help us define  
4 flux through the system, and that gets us an answer into  
5 potential dilution and travel times.

6           Major discharge areas for this region include Ash  
7 Meadows, Death Valley, areas like Oasis Valley up by Beatty,  
8 Sarcobatus Flats north of Beatty, and then some smaller areas  
9 to the south in the areas of Shoshone and Tocopala.

10           Dick Parizek had mentioned that there's a whole  
11 series of water level observations. This is a distribution  
12 of water level observations in the region. Obviously, the  
13 largest number of water level observations are in Las Vegas.  
14 Unfortunately, Las Vegas is not in our flow system, so we  
15 can't really use that information in our flow modeling.

16           The concentration of observations occur at Pahrump  
17 Valley, Amargosa Valley, Yucca Mountain, Yucca Flat and  
18 Pahute Mesa.

19           So while there is a lot of data on a local scale,  
20 on a regional scale, we really have some major gaps in our  
21 data set, particularly up in the northeastern part of the  
22 flow system, what is traditionally known as the Ash Meadows  
23 Flow System.

24           Using all of this different information, we took  
25 the Death Valley Basin, and we broke it down into what we

1 call three subregions, and the areas that you're seeing in  
2 white here are the areas that we included in our ground-water  
3 flow model. We broke the system down into a northern  
4 subregion, a central subregion and a southern subregion, and  
5 these subregions are defined as such because there's very  
6 little flux or ground-water movement between these basins.

7           The central Death Valley subregion includes Yucca  
8 Mountain, it includes Beatty, Amargosa Valley, and what is  
9 traditionally known as the Ash Meadows Flow System. To the  
10 south, we have sometimes we call it the southern subregion,  
11 the Pahrump, Shoshone subregion because that's flow from the  
12 Spring Mountains through the Pahrump and Shoshone areas. And  
13 then to the north, that includes areas like Lida Junction,  
14 Scottie's Castle, that type of thing.

15           We characterized the system and broke it down into  
16 what we called ground-water basins and sections. Each  
17 ground-water basin is named for the major discharge area. So  
18 our Pahute Mesa, Oasis Valley ground-water basin, major  
19 discharge at Oasis Valley, our Ash Meadows ground-water basin  
20 has major discharge at Ash Meadows. And then our Alkali  
21 Flat-Furnace Creek ground-water basin has major discharge at  
22 Alkali Flat and Furnace Creek.

23           This not, you know, earth shattering, ground  
24 breaking information here. This is basically a summary or  
25 work that had been done in the past, but we're kind of

1 packaging it and breaking it down so that we have a better  
2 way of doing an accounting when we do our ground-water  
3 budget. Characterize major ground-water flow paths. A  
4 similar exercise was done for the northern subregion. Here,  
5 major discharge in the northern subregion to Grapevine  
6 Springs out by Scottie's Castle. And then in the southern  
7 subregion, major discharge to the areas of Shoshone and  
8 Tecopa by way of Pahrump.

9           In our ground-water flow modeling, while we're  
10 calibrating, we're evaluating various conceptual models, and  
11 we're changing our interpretation of the hydrogeology, and  
12 these are some of the features that we pinpointed as key  
13 controls on the flow system, things like northeast and  
14 southwest trending high K zones, large hydraulic  
15 conductivity, high permeability zones. Okay, these are fault  
16 zones, big regional fault zones.

17           Northwest, southeast trending low K zones, the  
18 presence of a shale confining unit known as the Eleana on the  
19 test site, also very low permeability rocks in the Funeral  
20 Mountains right outside the window here, as well as  
21 Precambrian basement rocks. Critical to defining the flow  
22 system is this configuration of the carbonate aquifer which  
23 underlies the majority of the area, and that's the control,  
24 that's the key.

25           Along with the calibration, once we had flow lines

1 out of our calibration, we took a flow path. We plotted that  
2 onto a map, and then we also pulled up our hydrochemical data  
3 base, and we tried to see where we had hydrochemical  
4 sampling. What this does is it gives us an idea potentially  
5 of how hydrochemistry evolves down a flow path. And so what  
6 we're using is we're using our flow model, and we're using an  
7 independent check to see if that flow model flow path is a  
8 likely representation of the flow system, and we're using  
9 hydrochemistry as an independent check, and I believe Zell  
10 Peterman will also talk some more about that.

11           So what did we learn? Well, we were able to  
12 characterize in a three dimensional manner the system,  
13 locating regional and subregional boundaries, flow paths,  
14 discharge areas. We noted the importance, the very, very  
15 significant importance of the Death Valley salt pan as the  
16 major discharge area in the flow system, and how critical it  
17 is to measure that flux from the salt pan.

18           We noted the significance and the complexity of the  
19 framework and how changes in our framework interpretation can  
20 change the results of the flow model. So understanding the  
21 framework is the key to getting a good representation of the  
22 flow system, and then also the configuration, the geometry of  
23 this carbonate aquifer.

24           One of the first scenarios that we used the flow  
25 model for was to use it to evaluate changes in climate and

1 how that would affect the flow system. We had two  
2 simulations. We did a simulation of a climate for 21,000  
3 years ago. This was the close of the last major glacial.  
4 And then also a simulation of a potential global warming  
5 climate.

6           In the past simulation, we noted that recharge over  
7 the entire domain increased about five times. We got a water  
8 level increase over the entire domain, but this was  
9 dominantly within the upper layers. This was in their  
10 shallow system. What we noticed was that at Yucca Mountain,  
11 at the repository, we saw a 60 meter rise in the water table,  
12 north of the large hydraulic gradient, the 150 meter rise.  
13 This is well below the repository horizon. So based on this  
14 simulation, climate change, even a five time increase in  
15 recharge, would really have no effect.

16           On the future simulation, we saw 1 1/2 per cent--  
17 excuse me--a 1 1/2 times increase in recharge, and we only  
18 saw a 15 meter rise at the repository, again very well below.

19           The latest efforts in regional modeling have been  
20 to sort of combine data and information being conducted by a  
21 lot of other programs, federal programs within the Death  
22 Valley Basin. Along with Yucca Mountain site  
23 characterization, DOE folks on the Nevada Test Site have been  
24 conducting regional studies as part of their environmental  
25 remediation program, as part of the defense programs. The

1 National Park Service, BLM, State of Nevada, Nye and Inyo  
2 Counties are all out there conducting independent studies.  
3 And what the USGS, Yucca Mountain project and DOE have begun  
4 is an effort to combine all of these resources and data  
5 interpretations into a single comprehensive regional data  
6 base and flow model, cooperating with state, federal and  
7 local agencies. And the ultimate goal is not only to have a  
8 tool for site characterization, but to have a tool into the  
9 future that can be used for a ground-water management tool  
10 within the basin. So when we worry about or have concerns  
11 about development, increased ground-water withdrawals, this  
12 data base can be used for it.

13           And we see here on this slide, in solid line, you  
14 see the outline of the Yucca Mountain model, and then in the  
15 dashed, you see the outline of the model developed for the  
16 Nevada Test Site program.

17           The schedule for this study is to complete a  
18 revised steady-state representation of this flow model,  
19 similar to the one I just presented to you. This would be  
20 done by the year--by the end of fiscal year 2000, in time for  
21 the license application at Yucca Mountain, and then to  
22 develop a transient model for three years out. So we've  
23 developed a very good, very reasonable, very detailed  
24 representation of the flow system. That's being used  
25 currently.

1           And based on that model that we develop, we  
2 recognize the room for improvement, and we've begun the  
3 process of improving that model to develop an even better  
4 flow model. So part of the science effort here is to  
5 constantly improve our interpretations. And that's what I've  
6 got.

7           PARIZEK: Thank you, Frank. Paul Craig?

8           CRAIG: Yeah, Paul Craig, Board. A couple of questions.

9           This last slide suggests that you don't at the  
10 moment have a transient model. Does that mean you can't say  
11 anything about flow paths from the mountain once it hits the  
12 unsaturated zone--or the saturated zone, is the first part?  
13 I'll let you do these together. The second is a longer range  
14 question and the one I'm really interested in, and that has  
15 to do with stability of knowledge. We've heard a lot about  
16 changing interpretations of various aspects of the mountain.  
17 And my question for you is do you believe that understanding  
18 of the model is now stable in the following sense? You don't  
19 expect major conceptual surprises if you do additional  
20 research, and your values with the associated uncertainty are  
21 stable, in the sense that there is a high probability that  
22 the uncertainty bands won't change significantly.

23           And what I mean by stable is that if you were given  
24 an unconstrained research budget and unlimited time and no  
25 management constraints, you wouldn't get any surprises of the

1 sort that I described. That doesn't mean it wouldn't happen.  
2 But given the present state of knowledge, you don't think it  
3 would happen.

4 D'AGNESE: Sounds like a dream I've had several times.

5 Okay, the first question, we currently do not have  
6 a transient mode for the regional model. We have a steady-  
7 state model. A steady-state model does give us flow paths.  
8 It does define ground-water flow paths for us. What we don't  
9 have is a concept of travel time. We can build that into the  
10 flow model. It's not currently in the current published  
11 version. On the site scale, which John Czarnecki will  
12 present later on this afternoon, that model will have built  
13 into it, I believe he is calibrating in a transient mode,  
14 carrying it out many time steps.

15 So we can define flow paths currently. We don't  
16 have our finger on travel times yet. That's what we're  
17 looking to get with the additional studies.

18 We do not expect to see any new major changes in  
19 our interpretation. We do have some areas within the flow  
20 system where, you know, there's just absolutely no data, and  
21 unfortunately, some of these areas are relatively close to  
22 Yucca Mountain. One point that I'd point to is the Timber  
23 Mountain area just north of Yucca Mountain. We still don't  
24 have a lot of subsurface information north of Yucca Mountain.  
25 And so any new information we get there reduces our

1 uncertainty.

2       CRAIG: Do you anticipate no surprises if you were to go  
3 there? The question has to do not with collecting data,  
4 which one can always do, but rather with anticipation of  
5 surprises. If you drilled a hole there, is there any reason  
6 to believe you would be surprised?

7       D'AGNESE: I think that in some of these areas, there is  
8 potential for surprise because in some areas, we may think  
9 that we would not expect to see the carbonate aquifer in the  
10 Timber Mountain area because it's a resurgent dome, you know,  
11 an old volcano type of thing, we might locate carbonate, and  
12 that would change the flow system in that area significantly.

13               So there's still some key areas where we may not  
14 have a high level of certainty. Now, what we do in our flow  
15 modeling is we track uncertainty in our observations as we're  
16 doing our ground-water modeling. And so one of the major  
17 tasks in our modeling study, along with just doing a model  
18 calibration, is also to track this uncertainty, and so we're  
19 constantly trying to reduce that uncertainty in observations.  
20 By reducing that uncertainty in our observations, we can  
21 reduce our uncertainty in the model. And so we will have at  
22 the end an assessment of what we think the regional flow  
23 paths and travel times are, and what our level of uncertainty  
24 and certainty is. So that is a product. That's built in.

25       PARIZEK: Dan Bullen?

1 BULLEN: Bullen, Board.

2 Could you go back to your geochemistry slide,  
3 Number 16?

4 D'AGNESE: Okay.

5 BULLEN: And as I understand it, this slide basically  
6 tells you the change in the chemistry of the water as it  
7 flows through the flow field; that's what the significance  
8 is?

9 D'AGNESE: Yeah. What we're showing is that the  
10 discharging area is here at Grapevine Springs, and what we  
11 see are areas like at Lida Valley Well, Carter Spring, O'Hara  
12 Spring and Bonnie Claire Airport, those are further up the  
13 flow line toward the recharge area.

14 Now, as these move toward the discharge area, they  
15 mix and the chemistry changes, and ultimately, we end up with  
16 a chemistry that we would see at Grapevine Springs.

17 BULLEN: I guess the question is with your future  
18 predictions where you noted water table rise, would you be  
19 able to predict the change in the geochemistry of the water,  
20 or are you going to go into a different stratus so that this  
21 data won't be relevant if I'm 40 meters higher at Yucca  
22 Mountain, or 150 meters higher, you know, north of the Timber  
23 Mountain area?

24 D'AGNESE: What we noticed when we did our climate  
25 change scenarios and we saw the water table rise, what you

1 would be concerned about is does the configuration of the  
2 water table change? Do the dominant flow paths change? And  
3 we really don't see that happening. Even at the 21,000 year  
4 ago climate scenario, you don't see the major regional flow  
5 paths changing. In other words, there's some really dominant  
6 structural geological controls that even under increased  
7 recharge, increased flux through the system, those flow paths  
8 are not changing. So the type of scenario that you're  
9 describing, you really would not see that occurring. You  
10 wouldn't have to worry about any dominant changes in flow  
11 paths as a result of climate change.

12 BULLEN: Thank you.

13 PARIZEK: Jared Cohon?

14 COHON: Cohon, Board.

15 On your Slide 11, you presented the subregions that  
16 you created, and you said that there's very little flux  
17 between these subregions.

18 D'AGNESE: That's correct.

19 COHON: What's the basis for that claim?

20 D'AGNESE: What we look for are major framework  
21 controls, major geologic structures that would be like the  
22 distribution of low permeability rocks along these  
23 boundaries. And what these boundaries represent are the  
24 continuation of very low permeability structures, land forms  
25 within the region. And we also look at the water level

1 observations. We develop an interpretation of dominant flow  
2 direction, and we see that these boundaries that we've  
3 defined here are pretty much what we would call a ground-  
4 water divide. So it's a high point in the regional  
5 potentiometric water table configuration.

6           We then take that and we stick it into the flow  
7 model, and we let the flow model calculate what the trends of  
8 ground-water flow are. The ground-water model again  
9 emphasizes that these are divides, ground-water divides  
10 within the system, and we only see very small amounts of flux  
11 in these areas.

12          COHON: Is this bearing up as you're starting the  
13 process of revising the model in light of the other work  
14 that's being done by DOE and DOD?

15          D'AGNESE: I didn't hear the first part of the question.

16          COHON: Are these subregion boundaries standing up as  
17 you're starting to do--

18          D'AGNESE: Oh, yeah.

19          COHON: So you're getting confirmation of that?

20          D'AGNESE: Here's a good example. The area you see  
21 dashed is the boundary used in another DOE NEVOO, Nevada Test  
22 Site model, and you can see that these used as their flow  
23 model boundaries, pretty much the same exact ground water  
24 divides that we were using. And what we're finding is that  
25 their interpretation--their simulation within the same domain

1 where the two models sort of overlay, are similar.

2 COHON: I'm assuming that these subregion boundaries are  
3 developed primarily from those cross-sections that you showed  
4 us. And are they using the same data to create their  
5 subregion boundaries?

6 D'AGNESE: With the Nevada Test Site model, they used  
7 the same data, but they also had supplementary data on top of  
8 that. So they had more recent data. They had--I hate to  
9 bring it up--but they had a larger budget. So they had more  
10 geologists.

11 So what we find is that there are no major changes  
12 in geologic interpretation with their data set and our data  
13 set, but there are some minor configuration differences. But  
14 those minor configuration differences do potentially have an  
15 effect on some of the flow paths in the area.

16 COHON: Okay. Second question. On the climate change  
17 simulation that you did, you assumed two times CO2 global  
18 warming.

19 D'AGNESE: Right.

20 COHON: How did you go from that to rainfall at Yucca  
21 Mountain, or on the region?

22 D'AGNESE: As part of the Yucca Mountain Site  
23 Characterization Program, climate studies were conducted by  
24 the National Center for Atmospheric Research. They developed  
25 a global model where they input--

1 COHON: That's fine.

2 D'AGNESE: Basically a global model, increased CO2.  
3 They developed the precipitation distribution.

4 COHON: Last question. This is not a well formed  
5 question because I don't fully understand it. I'm trying to  
6 understand the relevance of your model to Yucca Mountain  
7 itself. My feeling is that what you've got here is going to  
8 be gross in a spatial sense, and therefore, undoubtedly  
9 valuable in knowing where discharge areas are. I mean, we  
10 sort of know that, and you're confirming it. But, for  
11 example, if I wanted to predict dilution from discharges  
12 coming from the repository itself, is your model going to  
13 support that?

14 D'AGNESE: Whether we want to admit it to ourselves or  
15 not, Yucca Mountain is superimposed on a very significant  
16 carbonate system. The flow within the local Yucca Mountain  
17 system is controlled by that carbonate system. What we're  
18 doing here is helping to define the localized boundaries of  
19 this Yucca Mountain flow system. Okay?

20 What we're also defining is the flux into and out  
21 of that flow system, and the only way we can get at that is  
22 by developing a model of this scale. If we just put a box  
23 around Yucca Mountain and modelled it as if the rest of the  
24 world didn't matter, we wouldn't get that amount. We'd have  
25 to back calculate it. And that's nothing to, you know, rest

1 your hat on.

2           So dilution comes from flux. Flux at local scales  
3 come from flux at regional scales. It's the only way we  
4 could get at it. So, yes, it has a very important--it's a  
5 very important control on our understanding of flux and  
6 dilution.

7       PARIZEK: Debra Knopman?

8       KNOPMAN: Knopman, Board.

9           Just following up a little bit on that, in the  
10 Yucca Mountain area, you don't have the saturated zone; it's  
11 above the carbonate aquifer.

12       D'AGNESE: That's correct.

13       KNOPMAN: Okay. And so you've got some presumably then  
14 different flow regime, different controls on flow in that  
15 area. What, and maybe you said this, I know you've divided  
16 your model up into these zones, but what sort of  
17 discretization in at least the Yucca Mountain area does your  
18 regional model have? And this question is leading to the  
19 water budget questions of really how much do we know is  
20 coming into that area and going out, coming through that flow  
21 cell?

22       D'AGNESE: We get at this by two different ways.

23 Geologically, what we've done with the regional scale model  
24 is we've broken into major what we call hydrogeologic units.  
25 Within the model, particularly around Yucca Mountain, we

1 have the carbonates. Okay, that would be the blue. We've  
2 also broken down the volcanic system into three major units,  
3 dominantly the welded volcanic rocks and the non-welded  
4 volcanic rocks that you hear so much about at Yucca Mountain.

5           Spatially, what we have in the model is a  
6 discretization of one and a half kilometers. So each one of  
7 these little blocks that you see here are one and a half  
8 kilometer blocks. In the vertical, our regional model is  
9 broken down currently into three layers. Those three layers  
10 are at 500, 750 and 1500 meter thicknesses. So your 500  
11 meter would be somewhat thinner, somewhat thicker and then  
12 the thickest would be at the bottom. And the attempt there  
13 is to represent local, subregional and regional flow paths  
14 that are superimposed on each other.

15           Another approach may be to just take the model and  
16 to slice it into as many layers as you possibly can. The  
17 trouble there is as we get deeper into the system, we have  
18 less knowledge of what's going on there. So it's more  
19 appropriate to discretize larger chunks of mass.

20           So the discretization that we have there is  
21 appropriate for this scale of modeling. We develop a water  
22 budget for the system at that scale, and then we assess how  
23 much water is moving into or out of our Yucca Mountain  
24 domain. And then later this afternoon, you'll learn more  
25 about that site model and how that represents the detail at

1 Yucca Mountain.

2           KNOPMAN: Okay. Knopman, Board.

3                   From mod flow, you can tell a water budget per  
4 cell?

5           D'AGNESE: That's correct.

6           KNOPMAN: And then you have associated with that, some  
7 uncertainties?

8           D'AGNESE: That's correct.

9           KNOPMAN: Okay. But at present, you don't really have a  
10 handle on, or do you, can you give us an idea of what sort of  
11 uncertainty is associated with the water budget in the Yucca  
12 Mountain area of your regional model?

13           D'AGNESE: Yeah. The only way that we have of getting  
14 the dominant or the modeler's module would be  $Q$  in equals  $Q$   
15 out, flux in equals flux out. So the only way we could get  
16 at the flux out of the system, or the flux into the system is  
17 to go to each of these natural discharge points and measure.  
18 Okay?

19                   We had the opportunity to measure sites like Ash  
20 Meadows, Oasis Valley as part of either Yucca Mountain  
21 studies or other NTS studies, and the measurements that we're  
22 getting there are plus or minus 20, plus or minus 15 per  
23 cent. Okay? So that's about as good as it's going to get  
24 when you're measuring evapotranspiration off of some of these  
25 sites.

1           We still have some large uncertainties associated  
2 with like the Death Valley salt pan. Estimates in the past  
3 have ranged an order of magnitude, and so we still need to  
4 tie those down to reduce the uncertainty.

5           So I would say right now in the budget, in some  
6 parts of the domain, we may have an error as much as--you  
7 know, as small as 15 per cent. In other parts of the domain,  
8 we may have it as large as 50 per cent, perhaps larger. The  
9 only way we could reduce that is to actually go out and  
10 measure.

11          PARIZEK: Parizek, Board.

12           When you talk about the 1998 combination of data  
13 bases, is that mainly for the site scale model with the  
14 regional model, or does that also include, say, the NTS  
15 modeling efforts?

16          D'AGNESE: At the end of '98, what we plan to have is a  
17 combination of Yucca Mountain and NTS regional data bases.

18          PARIZEK: Okay. And then for the 21,000 year ago  
19 simulation, that was steady state. How close did you get,  
20 say, in terms of the water table configuration projected  
21 versus, say, known paleospring deposits? That's a  
22 calibration possibility--

23          D'AGNESE: Yeah, and we noted that. During that 21,000  
24 year ago simulation, we did have discharge in all of the  
25 paleospring discharges that we had dated as being 21,000

1 years old. So it was a direct match.

2       PARIZEK: Okay. And will the model be used to project,  
3 say, rate of water table configuration change with climate  
4 change? You go from 21,000 years ago to, say, present, and  
5 then with global warming. But in the future with the climate  
6 change, you could have a slow response to regional water  
7 table rises, and that drives the whole flow system.

8       D'AGNESE: Ideally, what you would like to see is to  
9 evaluate a gradual change of the system, the response of the  
10 system over time to those climatic changes. Is that what  
11 you're getting at?

12       PARIZEK: Yeah. Is that planned?

13       D'AGNESE: It's being proposed.

14       PARIZEK: Proposed, okay. And then pumpage, say, in the  
15 Amargosa farms area, you have a short period I guess of  
16 withdrawal implied in the transient model. Will there be a  
17 longer term greater volume of water withdrawal effect?

18       D'AGNESE: What's proposed in this timeline that I've  
19 just showed you now is to conduct a transient simulation  
20 during the entire historical record. So starting in about  
21 1913, out in Pahrump, we began pumping. We will track  
22 ground-water withdrawals throughout the entire basin from  
23 about the turn of the century to present. So all of those  
24 time steps will be included.

25       PARIZEK: But no future--

1 D'AGNESE: It's proposed, but it would probably be, you  
2 know, further down the line.

3 PARIZEK: Priscilla Nelson?

4 NELSON: Nelson, Board.

5 This might be a little naive, but there's general  
6 extension going on as an ongoing process in the basin range  
7 area. To what extent can your model accommodate the changes  
8 in hydraulic conductivity and maybe even changing in  
9 discharge points or flow paths that might happen as a result  
10 past or future on the overall hydrologic model that you've  
11 created?

12 D'AGNESE: That's an excellent question. We've  
13 incorporated into this flow model, a structural model. What  
14 we've noticed is that the major discharge points throughout  
15 the entire region, Ash Meadows, Furnace Creek, these  
16 discharge areas are typically where a northwest-southeast  
17 trending, low K zone, which is in relative compression, is  
18 intersecting with a northeast-southwest trending zone that's  
19 in relative extension. Those zones are placed in the model  
20 explicitly so that we can actually go in and change the  
21 hydraulic conductivity, the permeability of these zones, to  
22 account for exactly what you're describing.

23 So it was all part of the original objective to  
24 evaluate structural changes within the region. So that whole  
25 scenario has been built into the flow model so they can be

1 conducted. We have not yet conducted it, but the opportunity  
2 is there.

3 NELSON: And do you expect to include the idea of  
4 localization that I could imagine, particularly with  
5 carbonate has a head on it that causes upward flow; isn't  
6 that correct?

7 D'AGNESE: Yeah.

8 NELSON: So that you could actually introduce some  
9 discharge points or turn them off?

10 D'AGNESE: That's correct.

11 NELSON: As a function of this.

12 D'AGNESE: Yeah, you would expect to see that.

13 PARIZEK: Other Board questions? Staff? No staff? We  
14 do have one member of the public who has a tight schedule, so  
15 we'll take his question now. Please state your name.

16 DALEE: My name is Michael Dalee. I will try to be back  
17 later, but I don't think I can. I just had a specific  
18 question.

19 I was looking for numbers. You mentioned something  
20 about discharge. I was looking for how you came up with any  
21 figures for recharge, if you just used earlier studies, I  
22 think most all of which go back to the Maxey-Eakin method of  
23 the Fifties? And if you have any acre feet numbers, I'd be  
24 very interested to hear those.

25 D'AGNESE: We can't directly measure recharge, and so we

1 get at recharge from reducing our uncertainty in discharge.  
2 The method used in the regional model was based on the Maxey-  
3 Eakin, although it's a modification of Maxey-Eakin. I don't  
4 have volumes, acre feet volumes off the top of my head.

5           My recommendation would be to get a copy of the  
6 report, WRI 96-4300. What we do is we break down each one of  
7 the surface water basins of the Death Valley Basin. We have  
8 estimates of recharge and estimates of discharge. So what  
9 we've done is a water budget accounting of the entire basin  
10 by what we call hydrographic area. But that is available.

11          COHON: If he gives you his name and address, could you  
12 send that for him?

13          D'AGNESE: I will do that.

14          COHON: Thanks.

15          PARIZEK: I think we ought to go on with our next  
16 speaker. Thank you very much, Frank.

17                 While Frank is getting unhooked there, I'll  
18 introduce Zell Peterman, who's going to talk about  
19 significance of hydrochemical domains in the saturated zone  
20 at Yucca Mountain. This is a fingerprinting of masses of  
21 water to see if it could help in any way to verify ground-  
22 water flow models, and also should help us with some  
23 understanding of the ages of the water, as well as evolution  
24 of the water in the flow path.

25                 Zell has been on the program and active with the U.

1 S. Geological Survey for a number of years, and brings a lot  
2 of credibility to the program.

3         PETERMAN: Thanks, Dick.

4             Yesterday, you heard Russ Dyer mention a couple of  
5 times the free emphasis of hydrochemistry in the project, and  
6 today, I'd like to summarize the USGS part of that, which has  
7 been in effect now for about three and a half months. In  
8 addition, right after me, you'll hear What Los Alamos is  
9 doing in terms of EH pH measurements and hydrochemical  
10 modeling. And I should mention a couple other efforts that  
11 are being valuable to the Yucca Mountain project, the NTS  
12 Environmental Restoration Program has a very aggressive  
13 hydrochemistry isotope effort on site being conducted, and  
14 this is mainly up at Pahute Mesa, Yucca Flat, conducted by  
15 Lawrence Livermore, and off-site, there's just a newly  
16 started Oasis Valley project which involves a number of  
17 participants, including Livermore, Los Alamos, USGS, both  
18 Nevada District and sub-district, people from the Yucca  
19 Mountain project branch, some of my people are working on it,  
20 DRI, UNLV.

21             Last summer, twelve new wells were drilled up north  
22 and northeast of Beatty. So this is a big effort. This is  
23 going to help us dramatically to understand the flow systems  
24 on a regional scale, and contribute to Frank's refinement of  
25 the model, the regional flow model.

1            Dick Parizek outlined the major saturated zones, or  
2 some of the major technical issues that relate to the  
3 saturated zone, in his introduction, and some of these same  
4 ones are shown here, of course, the amount of recharge  
5 through Yucca Mountain and the amount of water going through  
6 the saturated zone, reaching the water table at Yucca  
7 Mountain, extent of mixing. Some of the saturated zone  
8 experts have told us not to rely too heavily on mixing below  
9 the potential repository and also down gradient in terms of  
10 how much we can expect from dispersion. Matrix diffusion is  
11 always an issue in a fractured media, what sort of  
12 interaction is there between the matrix and the water flowing  
13 through the fractures.

14            Of course leakage from the carbonate aquifer, which  
15 has been mentioned already, delineation of up and down  
16 gradient flow paths, travel times; all these things are  
17 critical. I think the hydrochemistry and the isotope studies  
18 will contribute to a better understanding of many of these  
19 key issues.

20            What's USGS doing in the program? Our efforts for  
21 this last three and a half months have been sort of two-fold.  
22 We've been sampling and analyzing water from WT-24. I might  
23 mention that we do have analyses now from the first round of  
24 pumping at WT-24, and both dissolved ion chemistry, stable  
25 isotope, strontium isotopes, uranium isotopes, all suggest

1 strongly that that first water that was encountered is indeed  
2 perched. It has all the same chemical and isotopic  
3 attributes as the perched water at UZ-14.

4           So we're sampling wells. We'll be collaborating  
5 with Los Alamos and sampling some of the older WT wells.  
6 We're kind of behind schedule on that. WT-17 was scheduled  
7 to be sampled late last year, but it's been delayed mostly by  
8 the slowness of getting discharge permits.

9           We're also looking at the existing data. We're  
10 constructing an integrated isotopic/hydrochemical data base,  
11 and somewhat interpretative, there's a lot of data out there  
12 for some wells, there's so much data for the casual user,  
13 it's hard to know how to use the data. So we're evaluating  
14 the data. We're coming up with our best analyses. We're  
15 going to have a best composition of J-13, for example, which  
16 integrates the dissolved ion and the isotopic data, that sort  
17 of thing. So that's our data base approach.

18           One way we can use this data is what I call  
19 mapping. The Survey is good at mapping, of course, and we  
20 basically want to map out hydrochemical domains, and then of  
21 course to use these maps to delineate flow paths and to  
22 integrate that information into the regional flow model.

23           In terms of what I'm going to talk about today,  
24 late last year, we had our Level 4 models going, which  
25 integrated isotopic and dissolved ion chemistry for Yucca

1 Mountain proper, and this year, we're expanding that to the  
2 south, east, west and north. And basically, I'll just take  
3 that same Yucca Mountain rectangle and I'm going to move it  
4 south, which is what you see over on this other slide.

5           Last year, we were down to hear, and now we're in  
6 pretty good shape down this far. The slide on the left just  
7 is an image slide that shows relative elevation, because you  
8 don't get a feeling of elevation from the shaded relief map.  
9 So just to show that like everywhere else in the world,  
10 water pretty much runs downhill and does really follow  
11 regional topography.

12           The flow lines there on the left-hand diagram I  
13 think are pretty much consistent with the potentiometric  
14 contours in the regional flow system.

15           I want to mention these discharge sites were  
16 mentioned by Frank, Ash Meadows here where the regional  
17 carbonate aquifer discharge is, Franklyn Lake Playa where  
18 something discharges, I'm not sure we fully understand which  
19 system or what combination of systems, and then Death Valley,  
20 which is off this area here. Now, hopefully by the spring,  
21 we will have extended our refined data base both to the east  
22 and the west, and also to the north to take into  
23 consideration all of the new data that Livermore is  
24 generating up on Pahute Mesa.

25           The type of data that we have of course are

1 dissolved elements, minor and trace elements. Let me step  
2 back one point. When I mentioned the other work that was  
3 going on, I forgot to mention the work that's being conducted  
4 by UNLV, by Klaus Stetzenbach and his group over there.  
5 They're doing some very interesting regional studies using  
6 trace, dissolved trace elements, in particular things that  
7 they view as semi-conservative. So this is also going to be  
8 a very useful data set that will be incorporated into our  
9 thinking.

10               So we have the major elements, some minor and trace  
11 elements. We have the standard stable isotopes, oxygen,  
12 hydrogen, carbon isotopes, the radioactive isotopes, tritium,  
13 Chlorine 36, Carbon 14, a lot of interest in Chlorine 36.  
14 And I should mention that there's really a fairly large  
15 amount of data developing on Chlorine 36 in the saturated  
16 zone ground waters, and mostly on-site by Los Alamos,  
17 regionally by Livermore, and the patterns that are emerging  
18 are very interesting. I'm not going to talk about that  
19 today. There's just not time. But interesting regional  
20 patterns, and of course it was, you know, proposed years ago  
21 that Chlorine 36 might be a chronometer for ground water  
22 dating. It does not appear that that's going to be useful in  
23 this area. Obviously chlorine is not conservative on a  
24 regional scale.

25               Radiogenic isotopes, strontium and uranium; again,

1 we're developing a rather large uranium isotope data base,  
2 but there's really not time to mention that either.

3           One of our major analytical needs of course is a  
4 reliable method to date ground water, and this of course is  
5 not unique to Yucca Mountain. It's a widely needed  
6 technique. Carbon 14 of course is--conventional Carbon 14  
7 without interpretation is inadequate. In order to interpret  
8 it, you have to model it, so there's always questions on how  
9 you model the conventional Carbon 14 ages.

10           I think there is one hope, and that is this  
11 technique of separating out the dissolved organic carbon,  
12 which should come from recharge from the dissolved inorganic  
13 carbon, which is acquired along the flow path, and then if  
14 these can be separated, then you date the dissolved organic  
15 carbon. And from the work of Jim Thomas in Southern Nevada,  
16 including work on Ash Meadows, to me it looks very  
17 encouraging.

18           The travel times for the Ash Meadows system have  
19 gone from as much as 30,000 years ago, 30,000 years two  
20 decades ago, to probably less than 2,000 today. The other  
21 thing that argues that that dating is appropriate there is  
22 the fact that such a crisp climate signal is sequestered in  
23 those carbonates at Devil's Hole. If you had a long flow  
24 path or multiple flow paths of different lengths, you would  
25 blur that signal, and that signal is just as crisp as the

1 Marine isotopic signal.

2           Okay, let's push on here. Stable isotope data;  
3 this is all the stable isotope data that exists in that  
4 rectangle. And interesting things here; current  
5 precipitation of course would have a wide range from down in  
6 here to up here, and average, you might say average current  
7 recharge would be somewhere in this region here. The  
8 interesting thing here of course is the results from Franklyn  
9 Lake Playa, which show this classic evaporation curve,  
10 tremendous evaporation occurring there, which modifies the  
11 chemistry.

12           I think with this sort of relationship, we have the  
13 hope of taking this sort of thing, calculating how much  
14 evaporation has occurred, going back to the dissolved ion  
15 chemistry and then reconstructing what the apparent would  
16 have been, and then hopefully using that reconstruction to  
17 identify what water was in the Franklyn Lake Playa. The  
18 question of course is it Ash Meadows water from the region of  
19 carbonate, is it Yucca Mountain water, or is it water coming  
20 down the Amargosa, or is it some combination of any of those  
21 three.

22           Let's look at the hydrogen isotopes. Of course  
23 hydrogen and oxygen are conservative, or considered to be  
24 conservative from recharge. I apologize for these maps. Had  
25 I known the room was this long, I would have tried to make

1 these illustrations larger. And I won't spend much time,  
2 except as I go through these, what you'll see is different  
3 isotopic and hydrochemical domains emerge, and then we have  
4 to ask the question what do these domains mean.

5           Our first step is trying to map these out. Let me  
6 just point out a couple of things. There are several  
7 features on here. This well over here and this closed  
8 contour produces very little from late protozoic clastic,  
9 very tight late protozoic clastic rocks. It looks to me like  
10 that water is not moving very fast, has a deuterium content  
11 less than minus 110, 112, I think it's minus 115. It's  
12 probably the oldest water in the region. Clearly, it was  
13 recharged back in the Pleistocene in order to get water that  
14 late.

15           There's another closed contour up here in Crater  
16 Flat and the west side of Yucca Mountain less than minus 104.  
17 There's much heavier water coming down Forty Mile Wash,  
18 which is much more like modern recharge. So clearly, we're  
19 seeing these domains, these closed screwy looking contours  
20 down here of course reflect the evaporation that's occurring  
21 at Franklyn Lake Playa.

22           And I should say these data have been gridded.  
23 Obviously they're not optimal for gridding, and I should, you  
24 know, blank some of these out. I wanted to show the  
25 geography. So, you know, there are edge effects, in other

1 words. Things as you get out near the edge of the map where  
2 there's no data, there's strange things happen and the  
3 program wouldn't be too concerned about it. We'll trim those  
4 out eventually.

5           Oxygen of course is coupled with hydrogen and there  
6 are no surprises here. Again, you see a very light oxygen  
7 down here at this well that's in the Precambrian. You see  
8 the effect of evaporation. You see this closed contour up  
9 here at Yucca Mountain. Oxygen varies eight times less than  
10 hydrogen, so you don't get the same numerical resolution that  
11 you do with hydrogen or deuterium.

12           Strontium. Ground-water attains a strontium signal  
13 at recharge, and then as it moves along a flow path is slowly  
14 modified due to interaction with the aquifer minerals.  
15 There are some very systematic patterns here. We get low  
16 values at Yucca Mountain. We get a difference here between  
17 the main part of Yucca Mountain and Forty Mile Wash, which  
18 shows up in a number of these parameters as we go along.

19           An interesting thing down here at Franklyn Lake  
20 Playa. Suddenly all this variation that we get up gradient  
21 converges, and the Ash Meadows water has a very limited  
22 variation in strontium, and it may be that it's due to  
23 mixing, and it may be related, you know, to density driven  
24 mixing in the playa itself. The absolute values of strontium  
25 at Franklyn Lake Playa are intermediate between Ash Meadows

1 and the larger values coming down in the Amargosa here. So  
2 it could be that that data is telling us that we have a mixed  
3 signal coming out of Franklyn Lake Playa.

4 Chloride is often considered to be conservative,  
5 and I think I'd rather use the term semi-conservative. With  
6 this slide now for chloride, we start to see some things that  
7 you'll see in subsequent slides. You start to see there is a  
8 tongue or plume or whatever you want to call it of low  
9 chloride water. I've had to use the log of chloride here  
10 because from Yucca Mountain to Franklyn Lake Playa, there's a  
11 four orders of magnitude increase in concentration. So if  
12 you use a linear plot, you know, basically that will bulls  
13 eye down here, and nothing else in the whole map.

14 So there appears to be this plume coming southward.  
15 Now, I want to point out one thing. We've got lots of data  
16 down here in springs and supply wells in Amargosa, and quite  
17 a bit of data at Yucca Mountain. We've got a big gap in  
18 here, so we're really extrapolating some of these features  
19 through an area where we don't have a whole lot of data.

20 Other things; this string of points over here is  
21 the Ash Meadows discharge spring line, and that will show up  
22 in a number of chemical parameters. The difference between  
23 these southern springs and the rest of them also will appear.

24 Sulfate is often also considered to be what we call  
25 semi-conservative. The same type of pattern emerges here.

1 You have low sulfate values at Yucca Mountain. For some  
2 reason, the contouring program did not connect this low here  
3 with this low here, and it was certainly reasonable to do so,  
4 but it didn't connect it, again, because of lack of data  
5 here.

6           Two other things up here at the latitude of Yucca  
7 Mountain. Over in Jackass Flats, two wells were initially  
8 drilled. J-11 was drilled as a supply well. It turned out  
9 to have such high sulfate contents that it was abandoned. It  
10 couldn't be used for drinking water. So it's distinctively  
11 different than the Yucca Mountain water.

12           Over here in Crater Flat, there are two wells less  
13 than two miles apart, VH-1 and VH-2, and they have markedly  
14 different water compositions, in spite of the fact they  
15 produce from the same volcanic unit. We're seeing an  
16 enrichment of sulfate down here at Franklyn Lake due to  
17 evaporative concentration. Franklyn Lake is also a sink for  
18 certain elements because there are minerals precipitating,  
19 mostly calcium and magnesium bearing minerals, so you can't  
20 use the uncorrected, say cation ratios, to try to trace back  
21 water compositions, because things are not staying in  
22 solution.

23           This is just a summation of the alkalian earth's  
24 calcium and magnesium. Again, you see this what appears to  
25 be a tongue or plume of water coming southward. You're

1 seeing some strange things here at Ash Meadows, with some  
2 high calcium magnesium. I think these are wells here. And  
3 then when you get to Franklyn Lake Playa, you see low values,  
4 because calcium and magnesium is precipitating out as  
5 calcite, montmorillonite, that sort of thing sepiolite.

6           The alkalis are a little different. Again, you see  
7 that--

8           PARIZEK: Excuse me, Zell. Do you want to maybe stand  
9 to one side a little bit? Because you're apparently blocking  
10 our view.

11          PETERMAN: Okay. You see this same plume or tongue or  
12 whatever coming southward. You see an enrichment again.  
13 This is an evaporative enrichment down here at Franklyn Lake  
14 Playa. So the same patterns are emerging in these different  
15 chemical and isotopic parameters.

16           Look at the ratio between those two elements, which  
17 is always useful. You get a little, even a different  
18 perspective, and it shows up a couple things which I want to  
19 mention. Here again there's a low, there's this difference  
20 between eastern and western Yucca Mountain in terms of the  
21 ratio, the western Yucca Mountain samples tending to be more  
22 sodic than the eastern. A marked difference over here at  
23 Jackass Flat, tremendous difference here between VH-1 and VH-  
24 2, and this is where I think you have to start to look at the  
25 chemistries as certainly suggesting the possibility of

1 compartmentalized flow.

2           The geologic control here is that, you know,  
3 there's this line of craters, volcanic little cinder columns  
4 over here on Crater Flat from whence the name comes, and one  
5 of the wells is on the west side, VA-2 on the west side, and  
6 VH-1 on the east side. Now, it's certainly possible there's  
7 some sort of feeder drive going up in Crater Flat and it's  
8 causing a hydraulic impediment to communication. I don't  
9 believe that when you construct the isopleths here, of course  
10 you get these gradients. I doubt that there's a  
11 compositional gradient. I think there's probably a  
12 compositional discontinuity between those two ground-water  
13 domains.

14           Let's see, what else? The other thing that stands  
15 out very nicely of course is the Ash Meadows discharge and a  
16 high calcium-sodium ratio is characteristic of the regional  
17 carbonate water compared to the water that's in the volcanic  
18 aquifer. And, again, the ratios decrease down here because  
19 calcium and magnesium are precipitating out as calcite and  
20 sepiolite.

21           So with the domains that we have, I think that we  
22 can currently define on the basis of the hydrochemistry. I  
23 think I've tried to point them out as we've gone along here.  
24 Jackass Flat, where we have the high sulfate in water of J-  
25 11, Forty Mile Canyon, which has stable isotopes closest to

1 modern recharge, has the youngest Carbon-14 ages. It's  
2 probably the youngest water in the system. It's certainly a  
3 preferential pathway. The corrected Carbon 14 ages suggest  
4 that water from the upper reaches down to J-12 or J-13 is  
5 probably taking several thousand years.

6           We have the Yucca Mountain domain, east and west  
7 half, with a difference in the alkalis and alkaline earths,  
8 the Crater Flat domains. Certainly the eastern part of  
9 Crater Flat, VH-1, is indistinguishable from the Yucca  
10 Mountain waters. The western water in VH-2 has water that  
11 looks very much like water from the regional carbonate  
12 aquifer. It may simply reflect some degree of recharge  
13 through Bare Mountain, which is immediately to the west.  
14 Down gradient domains, the Amargosa Desert; in a number of  
15 the maps you saw there were closed isopleths down there,  
16 which indicated complexity and we're probably looking at  
17 mixing between the Forty Mile Wash system, the Yucca Mountain  
18 system and the Crater Flat system.

19           The Ash Meadows domain of course is discharged from  
20 the regional carbonate aquifer, and the Franklyn Lake Playa  
21 domain is a domain that's characterized by evaporation and  
22 concentration of dissolved ions and modification of stable  
23 isotopes.

24           So I think what we're looking at this year, we want  
25 to continue on with getting our refined data base together

1 that integrates the isotopes. As we went through the maps,  
2 you saw that we have a lot of dissolved ion chemistry. We're  
3 really weak on isotopic data, especially down gradient. So  
4 what we want to do is in the next few months, come down here,  
5 try to resample a lot of these supply wells, build up our  
6 isotopic data base. I think that's going to help us probably  
7 as much as anything in trying to delineate these down  
8 gradient flow paths.

9           We'll continue to sample the new wells up at Yucca  
10 Mountain, SD-6, saturated one. We hit the saturated zone at  
11 WT-24, plus next year, SD-9 and SD-11 and 13. We want to try  
12 to get back into some of the WT wells, Los Alamos will  
13 resample those.

14           Basically, we're aiming at better delineation of  
15 flow paths, and of course we have to move up gradient also  
16 and incorporate that data. We have to understand what is  
17 coming into the system from the north, and that's mainly--we  
18 won't be gathering any new data up there. We'll be  
19 integrating what Livermore has produced for the environmental  
20 restoration program.

21           PARIZEK: Thank you, Zell. It's a lot going on in a  
22 short time, but it's based on years of background work.

23           Board members with questions? Yes, Paul Craig?

24           CRAIG: Craig, Board.

25           There was a lot of information. That was

1 wonderful. For our purposes, one of the things we're most  
2 concerned about is the travel time through the saturated  
3 zone, obviously, and you gave us a set of numbers that had  
4 something to do with that. What I'd like to ask you to do is  
5 to give your best estimate, given your whole body of  
6 knowledge, on what is a reasonable travel time for Yucca  
7 Mountain water once it hits the saturated down, down into the  
8 valley, and what kind of standard deviation would you assign  
9 to that?

10         PETERMAN: I'll probably equivocate on that. There's a  
11 lot of conventional Carbon-14 data, there's a lot of Carbon-  
12 14 data for the wells up here in the Amargosa. They're  
13 running from, uncorrected, 10,000, 15,000 years. Clearly,  
14 they've incorporated dead carbon, so that has to be corrected  
15 out.

16         Ed Kwickless has been working on modeling the  
17 conventional Carbon-14 ages at Yucca Mountain. He generally  
18 reduces the ages by modeling by, oh, say several thousand  
19 years. In terms of flow velocity, I'd have to calculate  
20 that. Coming down from the upper reaches of Forty Mile Wash,  
21 UV-19, A-1 and 2 are up in here, and Jim Thomas at the  
22 district office is currently doing Carbon-14 on the dissolved  
23 organic carbon, and we think he's going to get zero. We  
24 think there's recharge up there.

25         And then you've got wells down here that are giving

1 corrected ages of 4,000 to 5,000 years. So whatever that  
2 distance is, and I know--well, I've got a scale here--  
3 whatever that distance is, divided by--or divide 5,000 years  
4 by that distance, and that's the best control we have.  
5 That's only on Forty Mile Wash. Forty Mile Wash is a domain  
6 in the system. It's probably a preferential pathway. So I'm  
7 not going to give you a figure.

8       CRAIG: Well, what is emerging from what you just said  
9 is a time like 5,000 years.

10       PETERMAN: Yes. What I'd really like to say is I think  
11 we've got hope in answering that question. I don't think we  
12 have the answer right now. I think we get in there, get  
13 dissolved organic carbon, C-14, we're going to get some good  
14 realistic ages on the time between recharge and where that  
15 water is now, and then, you know, incorporate that into the  
16 model, we are going to be able to come up with some answers.  
17 I don't think we have them right now.

18       CRAIG: What's the probability that it's a thousand  
19 years or less?

20       PETERMAN: I think that's extremely remote based on what  
21 we see at Yucca Mountain. I think Forty Mile Wash is  
22 probably as fast as it gets, and there we're talking about  
23 5,000 years over a few kilometers.

24       CRAIG: Okay. That's pretty helpful.

25       PARIZEK: Alberto Sagnes?

1 SAGYES: Yes, Sages, Board.

2 Down at the Franklyn Lake Playa that will be  
3 presumably one of the areas where some of the radionuclides  
4 may be emerging, what is the likelihood that there will be a  
5 concentration of those radionuclides at the surface of the  
6 playa?

7 PETERMAN: Well, anything that's in the water going into  
8 Franklyn Lake Playa is concentrated by evaporation. So  
9 anything that's dissolved will be concentrated.

10 SAGYES: Can you envision any scenario where a good  
11 fraction of the radionuclides will end up piling up and  
12 reconcentrating?

13 PETERMAN: I think that's something that with the  
14 refinement of the hydrochemical and isotope data, attempting  
15 to incorporate that into the regional flow model, right now,  
16 there's some debate what proportion goes to Franklyn Lake,  
17 what proportion goes to Death Valley. With a long enough  
18 flow path, of course it's sort of immaterial. By the time it  
19 gets to Franklyn Lake Playa, you know, you may be talking  
20 5,000, 10,000 years. So much of the material will already be  
21 decayed. You'll have some exotic elements, but they're  
22 certainly not going to be a hazard.

23 PARIZEK: Priscilla Nelson?

24 NELSON: Nelson, Board.

25 I must admit I'm a little bit confused. You've got

1 a lot of well information there, and then contours made. Are  
2 all the wells developed in the carbonate aquifer in all  
3 cases?

4       PETERMAN: No. I should have mentioned that. This  
5 approach to try to display the data using these isopleths  
6 does not consider the third dimension. Now, down here in  
7 Amargosa Farms, all the wells produce out of the alluvium,  
8 and there's certainly a depth difference, too, and that's  
9 something we have to look at. Frank's group is developing a  
10 parallel data base where they will try to incorporate all  
11 this third dimensional information into their data base.

12           For Yucca Mountain, you know, the wells produce  
13 from different volcanic units. Basically, as you go from  
14 west to east, the saturated zone is moving into the--let's  
15 see, how does that work--it moves from the older into the  
16 younger, tends to move from the older into the younger  
17 volcanic units, although it's all chopped up by faults, so  
18 there's not a real consistent pattern. Right now, we're not  
19 considering--our isotopes, say our strontium isotopes, which  
20 you would think would be sensitive to water-rock interaction,  
21 it doesn't matter at Yucca Mountain whether we're producing  
22 from the Calico Hills or the Prow Pass or the Topopah Spring,  
23 and we have wells from all of those, the isotopes are the  
24 same, which suggests that water-rock interaction is very low.

25           But to answer your question, there's only one well

1 at Yucca Mountain, and that's P-1 that goes into the  
2 Paleozoics. All these others are in either the volcanics or  
3 alluvium, with the exception of the spring discharge at Ash  
4 Meadows, which everybody agrees is the regional carbonate  
5 aquifer discharge.

6       NELSON: Okay. When you were talking about Forty Mile  
7 Wash and travel times, whatever, what unit was that travel  
8 time developed through?

9       PETERMAN: The wells J-12, J-13, those supply wells, JF-  
10 3 in Forty Mile Wash in the lower part there are all in the  
11 Topopah Spring. JF-3 produces--that's about the only neat  
12 well we've got. That was designed to only sample the water  
13 in the Topopah Spring. J-13 gets 90 per cent of its water  
14 from the Topopah and about 10 per cent from another spring,  
15 which is down in the Prow Pass. J-12 gets most of its water  
16 from the Topopah.

17               In the upper reaches, UV-29, A-1 and 2, those are  
18 in the alluvium. The deeper one goes down into bedrock. So,  
19 you know, you never quite have everything you want when it  
20 comes to wells and where they produce water from. But  
21 there's an awful lot of useful information.

22       PARIZEK: I was going to ask a question, Parizek, about  
23 the twelve wells up at the Beatty flow system. That's a lot  
24 of commitment. You mentioned a whole group of people doing  
25 that work.

1           PETERMAN:  Yes.

2           PARIZEK:  Is that driven by NTS concerns?  It would seem  
3 like Yucca Mountain flows are more apt to come down in the  
4 Amargosa Valley area where we are here.  Why not 13 or 12  
5 wells on 95 and somewhere in that area to resolve some of the  
6 things you point out where you have data deficiencies; why  
7 Oasis Valley emphasis?

8           PETERMAN:  The Oasis Valley project is driven by the  
9 concern about the possibility of movement from the  
10 northwestern part of the test site, Pahute Mesa.

11          PARIZEK:  So it's a test site driven concern?

12          PETERMAN:  Yes.

13          PARIZEK:  Should Frank stay alert and ready to go back  
14 to the drawing board in his regional model, based on the new  
15 data that you're putting together?  I mean, are there any  
16 surprises that you sort of see coming based on your isotopic  
17 work and all the chemistry work?

18          PETERMAN:  We've worked with Frank and been through one  
19 cycle, what, a couple years ago, of selecting certain flow  
20 paths and then testing, using the hydrochemistry to test.  
21 So, no, I don't think so.  I think one of the big questions  
22 is this discharge, down gradient discharge sites at Franklyn  
23 Lake Playa, Death Valley, what system is feeding what, or  
24 what combinations, those sorts of things that I hope we can  
25 de-convolute by getting a better look at the isotopes and the

1 hydrochemistry.

2       PARIZEK: The present concern is Franklyn Lake Playa is  
3 probably mixed waters; it's not a simple system necessarily.  
4 I mean, flow systems are coming from more than one  
5 direction.

6       PETERMAN: Yes, that would be my current feeling.

7       PARIZEK; And the time when you may get some documents  
8 together based on all of this activity, there's a lot going  
9 on in a short time, there's very powerful data, do you have  
10 some idea of when your deliverables might be expected?

11       PETERMAN: We're pushing--well, of course the sampling  
12 of the new wells depends on the drilling and when we can get  
13 into some of the old WT wells, which Arend will probably  
14 address.

15               In terms of the data base, you know, I'm hoping  
16 that by late this spring, we'll have pretty much everything  
17 that's available in this new integrated data base. I was  
18 just looking at the schedule, and somehow, I don't know how  
19 it happened, but we escaped having a milestone on that this  
20 fiscal year. I think it was part of the multi-year planning  
21 process where we encouraged not to pay attention to fiscal  
22 years, but pay attention to the work that needs to be done  
23 and when it needs to be done. So our milestones for the data  
24 base are next fiscal year, but that doesn't mean we're not  
25 going to continue to push it just as hard as we can, because

1 we need that data base in order to guide some of our new work  
2 down gradient.

3       PARIZEK: All right, thank you. Staff? If not, I think  
4 we ought to go on. It's an important discussion.

5               Our next speaker is Arend Meijer, and he'll talk on  
6 model for major ion chemistry of the saturated zone waters  
7 along flow lines through Yucca Mountain. He's with Los  
8 Alamos National Laboratory.

9       MEIJER: I have to apologize that the actual title of  
10 the presentation is going to be inferences from saturated  
11 zone ground water chemistry and implications for transport  
12 parameters. The original presentation was going to be on a  
13 model for major element chemistry, but it was felt that  
14 coming up with these inferences and implications was more  
15 appropriate for this group.

16               I do have some slides concerning a model for major  
17 ion chemistry, and if there's interest, we can talk about  
18 that in the question and answer session.

19               This then is the title. The first slide may be a  
20 little imposing. I don't intend this to be a discussion of  
21 detailed chemistry, but we do need to discuss some chemical  
22 reactions, because they have implications for transport. And  
23 here, I basically reviewed some of the major chemical  
24 reactions that are likely to control water chemistry in the  
25 flow system that goes through Yucca Mountain. And this is

1 one of the reasons I borrowed a slide from Zell, and that is  
2 the discussion I'm going to present today is focused on this  
3 tongue of the flow system, and basically including the area  
4 to the north. That's the recharge area in Pahute Mesa and  
5 Rainier Mesa. So I'm going to concentrate all my discussion  
6 sort of on a flow line from the recharge area, down into this  
7 Amargosa Valley region. So I'm not going to worry too much  
8 about the carbonate aquifer. I'm going to concentrate on the  
9 volcanic aquifer.

10           That being the case, precipitation/dissolution  
11 reactions are important, particularly in the soil zone, but  
12 also in the UZ, and also particularly in recharge areas,  
13 because that's where most of the water chemistry for the  
14 waters that are found along that flow path are imposed.

15           Ion exchange is quite important. Ion exchange on  
16 zeolites, hydrogen exchange on glass and Feldspar, and then  
17 finally, hydrolysis reactions are important. This is  
18 actually probably better termed acid base reaction, but it's  
19 also hydrolysis reaction. These two reactions are probably  
20 too slow to have much impact on the water chemistry in the  
21 flow system that we're talking about.

22           Now let's talk about some of the inferences. In  
23 the next slid, I'll show that--well, first of all, the way  
24 that I set these up is I've presented some observations, some  
25 data, drawn some inference from that, and then given an

1 implication of that data in the inference.

2           First of all, the data suggests that the major  
3 constituent concentrations, that is, the major cations,  
4 anions and silica, show only limited variability in waters  
5 along flow lines from the recharge areas, Pahute Mesa,  
6 Rainier Mesa, down through Yucca Mountain into the Amargosa  
7 Valley. The inference is that these major constituent  
8 concentrations are buffered by water-rock reactions. The  
9 only reaction that seems to go on continuously is this one  
10 right here.

11           The implication is that the variations in  
12 concentrations of major constituents in saturated zone waters  
13 are unlikely to have a major influence on transport parameter  
14 values in the saturated zone.

15           The next slide is actually the following slide in  
16 your xeroxes, and what I've done here is just given you the  
17 compositions of major ions, major cations and anions and  
18 silica in three separate waters--actually four, but three of  
19 them from the flow system that we're interested in, these  
20 three right here.

21           This is water from a well in the recharge area.  
22 The well happens to be TW-8 right at the south end of Rainier  
23 Mesa, I believe. It's in tertiary volcanics, so these waters  
24 reflect a chemistry that interacted with tertiary volcanics.

25           The second water is a water that's halfway through the

1 flow system at Yucca Mountain, and certainly Zell has  
2 referred to this. This is J-13 water composition. Then,  
3 finally, here's a water composition that occurs further down  
4 the flow system in this region here. Actually, right in  
5 here. So I could have also taken additional compositions  
6 further down the flow path, but I chose one right down here.  
7 J-13 is up in here, and then TW-8 is up above the highest  
8 black dot that you see there.

9           The point that I'm making is that these three water  
10 compositions are actually quite similar, so that all along  
11 that flow path, there is not a whole lot of water-rock  
12 interaction that goes on to change the chemistry. What does  
13 go on is the pH increases significantly, also sodium  
14 increases somewhat, by a factor of two or so, and that's from  
15 this sodium-hydrogen ion reaction that I showed on the second  
16 slide. So the argument then is the water chemistry seems to  
17 be set in the recharge area, and from then on, there's not a  
18 whole lot of change until you start mixing waters from other  
19 flow systems, such as the carbonate aquifer water.

20           The one thing that we don't have good information  
21 on is redox potential, and I put question marks here. We're  
22 hoping to get additional information on redox potential in a  
23 number of wells at the site this year, and in fact hopefully  
24 within the next month or so. And I'll talk a little more  
25 about that later.

1           Okay, another set of data, inference and  
2 implications. The data is that the water along the flow  
3 paths, the ages of the water along the flow paths are  
4 whatever they are; I put up to 20,000 years BP here. That's  
5 a number that I've seen over the years. The number might  
6 actually be 15 or 10, and we can argue about that. My point  
7 is that the ages range up to some number like that.

8           The inference is that the time of infiltration of  
9 the water is not a major factor in controlling water  
10 chemistry, because we saw from the last slide, water  
11 chemistry doesn't seem to depend on where in the flow path  
12 you are, whether you're in the recharge area or down in the  
13 Amargosa Valley. So time of infiltration doesn't seem to be  
14 important. So the implication is that climatic variations  
15 aren't going to have a major impact on major element  
16 concentrations in the waters in the saturated zone within  
17 Yucca Mountain.

18           This slide talks to the relationship between the  
19 presentations in this meeting and the presentations that  
20 might be made in a strictly transport meeting where we talk  
21 about the potential transport of radionuclides along the flow  
22 path. Because in order to calculate transport, you need to  
23 have values for transport parameters, and the question is how  
24 do you get those values and what kind of water compositions  
25 do you use to get those values.

1 Well, the fact is that the project has used J-13  
2 water for a lot of experiments to obtain transport  
3 parameters, and I've said here J-13 is sort of in the middle  
4 of the flow path. The inference is that J-13 water is  
5 representative of the major constituents in saturated zone  
6 waters in the volcanic aquifers. The implication is that J-  
7 13 can be used in these experiment basically because the  
8 waters along the flow path don't seem to show that much  
9 variation.

10 Related to this is the fact that pH in the  
11 saturated zone waters does show substantial variation from  
12 6.5 to about 9. The inference is that there's something  
13 controlling it, and I've said partial pressure of CO<sub>2</sub> is a  
14 factor. There may be other factors as well. The implication  
15 is that we ought to do these laboratory experiments over at  
16 least this range of pH values in order to get transport  
17 parameters that can be applied generally.

18 This slide starts off the rest of the presentation.  
19 This gets us into an area that we're concentrating on at the  
20 moment and will for the rest of the fiscal year and possibly  
21 into the next fiscal year.

22 Here, the data is that the oxidation/reduction  
23 potential in saturated zone waters at Yucca Mountain shows a  
24 range from minus hundred something or other to 365  
25 millivolts, but we have very few data points, and those data

1 points were collected under conditions that are not  
2 necessarily optimum. And I'll get into that in more detail  
3 in a minute.

4           The other data point is that methane is found in  
5 some wells. So there is a suggestion there might be reducing  
6 conditions, at least in some wells.

7           Inference is that based on that range of values,  
8 the oxidation/reduction potential, or Eh, of waters in the  
9 saturated zone may be sufficiently low, that is, the waters  
10 may be sufficiently reducing so that the lower oxidation  
11 states of redox sensitive radionuclides are stabilized.

12           The implication is if those lower oxidation states  
13 are stabilized, then nuclides such as Technetium 99 and  
14 Neptunium 237 would be greatly retarded relative to the  
15 situation under oxidizing conditions. So it's quite  
16 important to determine whether the Eh of waters in the  
17 saturated zone is sufficiently reducing.

18           The data that we have to date, and I mentioned the  
19 range earlier, but basically this data was obtained by Al  
20 Ogard in 1984. There's a Los Alamos report here that  
21 presents that data. The data was obtained basically on  
22 pumped water samples, samples that were pumped from depth  
23 using metallic tubing and using a metallic pump and various  
24 other things that aren't necessarily optimum for obtaining  
25 the redox potential of the water that's 1,500 feet down in

1 the ground.

2           However, even under those conditions, they did see  
3 negative redox potentials, and overall, the average of the  
4 numbers that they obtained is something like 225 millivolts,  
5 and then there are also some lower values in some "thief"  
6 samples, basically dip a bucket down the well and pull up the  
7 water.

8           This average of 225 is very close to the potential,  
9 that is, the redox potential at which Neptunium goes from  
10 plus 5 to plus 4, and Technetium goes from plus 7 to plus 4.  
11 So the possibility exists that these radionuclides would be  
12 in the reduced form in the saturated flow system. So the  
13 rest of the talk then is about what we're going to do to try  
14 and resolve that.

15           This slide is thrown in here just to give you an  
16 additional handle on the radionuclides that are particularly  
17 pertinent to this discussion, and I won't go into the details  
18 there.

19           What we plan to do, and as I said, in the very near  
20 future here, we're going to make measurements on the redox  
21 state of saturated zone waters. We're going to make these  
22 measurements on waters that are pumped from the wells.  
23 However, the pumping systems are going to be essentially non-  
24 metallic. We'd have fiberglass tubing. We've got a non-  
25 metallic pump, and then the measurement equipment at the

1 surface will all be non-metallic, except of course for the  
2 platinum electrode.

3           Wells are going to be cleaned and purged  
4 beforehand, and the wells that we're starting on are WT-17,  
5 WT-3. These are two wells in Dune Wash down gradient from  
6 the potential repository. So those are important locations  
7 to have this sort of information for.

8           The pumped water will be monitored not only for the  
9 platinum electrode potential, but also for a number of other  
10 redox sensitive parameters. And those include various redox  
11 couples, including total iron, Iron-2, Sulfate, Sulfide,  
12 Nitrate, Nitride. And then with Klaus Stetzenbach at UNLV,  
13 we're also intending to do Selenate, Selenite, Arsenate,  
14 Arsenite, and a number of others, so that with that whole  
15 collection of data, we can bound the redox values in the  
16 saturated zone at the locations at which we sample it.

17           Zell talked about the work on major constituents,  
18 environmental isotopes and other work that he says the USGS  
19 will carry out.

20           In summary then, the variations in the major  
21 constituents along this flow path from recharge area to  
22 Amargosa Valley, or to the accessible environment boundary,  
23 wherever you want to put that boundary, the variations are  
24 unlikely to have a major impact on transport parameters,  
25 except perhaps for pH and Eh. We're doing the experiments

1 over a range of Eh, so we'll cover that base, and then the Eh  
2 measurements, we're going to do here shortly. And what that  
3 will require then is a more detailed analysis of how the  
4 observed pH values relate to the transport parameters. And  
5 that will be based on laboratory data.

6           Variations in climate are unlikely to have a  
7 significant impact, as I mentioned earlier. Water from Well  
8 J-13 seems to be close enough to representing the average of  
9 the waters in the volcanic flow path that it can be used.  
10 And then, finally, the redox potential in saturated zone may  
11 actually be sufficiently low to stabilize less mobile forms  
12 of some very important radionuclides that are now a problem  
13 for dose calculations.

14           Thank you.

15           PARIZEK: Questions from the Board? Paul Craig?

16           CRAIG: Craig, Board.

17           I'm struggling as a non-geologist to put these  
18 pieces together. So let me tell a story and tell me what's  
19 wrong with it.

20           You're telling us on your graph four that the time  
21 of infiltration isn't a major factor in control, which is  
22 encouraging. And then in addition, there's encouraging  
23 information in that Neptunium and Technetium, that they may  
24 not move as fast as the water. Zell has told us that 5,000  
25 years is a plausible time for the water motion. If you can

1 only get a factor of two out of your hold-up through the  
2 chemistry, you're now up to a time of travel in the saturated  
3 zones which is comparable to the times that are emerging in  
4 other pieces of the project, 10,000 years for the canister,  
5 and so forth.

6           If that's true, the saturated zone becomes an  
7 important and possibly even a determining hold-up time.  
8 What's wrong with that reasoning?

9           MEIJER: I like it. Well, I mean I don't necessarily  
10 disagree with it, and in fact I think I agree with it.  
11 Basically, I think that the hold-up time in saturated zone  
12 may be more than a factor of two, particularly if the redox  
13 potentials are low enough to stabilize plus four neptunium  
14 and plus four technetium. So if the question is how could  
15 the retardation times be less than a factor of two, based on  
16 the water chemistry, about the only thing I could come up  
17 with would be pH, because that shows a significant range, and  
18 under low pH conditions, radionuclides stick less to the rock  
19 surfaces than under high pH conditions.

20           But the fact is that the pH increases down  
21 gradient, or seems to, based on the data we have, and so that  
22 doesn't seem to be a problem. So I don't see a problem with  
23 the conclusion at the moment, but I'd like some more time to  
24 think about it. But at the moment, I don't see a problem  
25 with it.

1           PARIZEK: Debra Knopman?

2           KNOPMAN: Knopman, Board.

3                    Wait a second. In interpreting your data from  
4 really just a couple of points here, you're sampling from the  
5 basically matrix waters as opposed to water that might be  
6 flowing through fractures where you're getting some mixture  
7 of those waters and you really--you're not talking about--or  
8 let me phrase this as a question. What really can you say  
9 about retardation between the repository site and discharge  
10 areas from, you know, five data points or less?

11           MEIJER: Your point is well taken. First of all, I  
12 can't say anything about retardation based on the major  
13 element chemistry. I mean, that's for a talk on the effects  
14 of major element chemistry variations on sorption  
15 coefficients, on solubility and all that. This talk is not  
16 that talk. Okay, that's the first thing.

17                    The second thing is that I've used three data  
18 points, but the fact is, as Zell showed, we have probably a  
19 hundred data point--well, a hundred may be a little much but  
20 certainly 50 data points along that flow line. So if you  
21 look at all the data, all the data would be consistent with  
22 this argument, you know, plus or minus some error, the  
23 argument that I've made. So those are the two main points.

24                    With regard again to the retardation, I'm also sort  
25 of calling on a previous life I had in sorption coefficient

1 determinations and transport parameter derivation, so I'm  
2 adding in here information that I haven't given here today,  
3 but that's in the literature that you have available and  
4 probably in other talks that you'll hear on that. Not here;  
5 not today.

6         PARIZEK: Parizek, Board.

7             Do you have any idea about the origin of the  
8 methane that you observed in wells? Is it really sedimentary  
9 bedrock units, or was that in the volcanics?

10         MEIJER: Well, first of all, I'm not the one that found  
11 it, so I don't know exactly the conditions under which it was  
12 found. But with that caveat aside, there are suggestions  
13 here and there that there are sources of methane somewhere  
14 down there, and the fact is that there are sources of  
15 petroleum fluids and such not too far north of the test site.  
16 And so the Paleozoic aquifer, that is the carbonates, have  
17 the potential of having some reducing substance in them,  
18 including methane. And so perhaps this stuff is coming from  
19 the paleozoics, I don't know, but it has been observed in  
20 more than one place, and beyond that, I can't really make any  
21 statements.

22         PARIZEK: But it would be good news in terms of the  
23 hold-up of, say, technetium and neptunium?

24         MEIJER: You bet.

25         PARIZEK: But the iodine then would be the last ringer

1 in terms of long-life nuclides?

2       MEIJER: Right. Iodine is actually interesting. We've  
3 taken the position to date, and again I'm talking about my  
4 previous life here, that iodine has no retardation  
5 whatsoever, and in fact may be ion excluded and, therefore,  
6 travels faster than the water on average. But once you start  
7 including an alluvium into the calculation, it turns out that  
8 iodine can be held up in alluvium and it seems to be a  
9 reaction in which iodide is converted to iodine, I-2, and  
10 that iodine seems to react with organic materials, even a  
11 small amount of organic material that somehow gets deposited  
12 with alluvial material.

13               So the possibility exists that as water comes out  
14 of the volcanic aquifers and goes down into the alluvium in  
15 the Amargosa Valley, that organic materials in that alluvium  
16 could retard the iodine. That's just a speculation on my  
17 part. But based on data that we have in the literature, in  
18 the peer review literature, and also an experiment done on  
19 alluvium from Yucca Flat by Kurt Wolfsberg in the Seventies,  
20 he saw retardation. So even iodine has got the potential for  
21 being retarded.

22       PARIZEK: Other Board questions? Staff questions? If  
23 not, we thank you for your presentation. And the next  
24 presenter before our break, and we still may make a break,  
25 has to do with hydraulic and tracer testing in the C-Well

1 complex by M. J. Umari and Paul Reimus from the U. S.  
2 Geological Survey.

3       UMARI: I'm M. J. Umari, the PI for hydraulic and tracer  
4 testing, conservative tracer testing at the C-Holes, and my  
5 colleague, Paul Reimus, is the PI for reactive tracer testing  
6 at the C-Holes, and he will be basically--I'll be presenting  
7 you with summary of hydraulic and conservative tracer  
8 results, and then he will be talking to you about reactive  
9 tracer results.

10           I've placed the C-Holes complex here in a large  
11 aerial context basically to point out two things. First of  
12 all, that the hydraulic tests that have been conducted here  
13 at the C-Holes complex have affected area much larger  
14 than the complex itself. They've affected WT-3 down here at  
15 about three and a half kilometers, WT-14, H-4 and C-1. So  
16 this is the first reason for placing it in the large aerial  
17 context like that.

18           Another one is to point out that all the hydraulic  
19 and tracer testing that has been done at the C-Holes is not  
20 intended to be the end product. The C-Holes were not  
21 constructed only to determine hydraulic and transport  
22 parameters at the C-Holes complex, but to determine  
23 methodology for characterizing fractured rock in the  
24 saturated zone, and that those procedures would then be  
25 carried out at other locations at the site. And that will be

1 a context for thinking of the second tracer complex which  
2 Paul Reimus will tell you about. The idea of that would be  
3 essentially to carry on the methodology that has been  
4 developed at the C-Holes to locations other than the C-Holes.

5 I'd like to basically tell you about a few  
6 hydraulic and tracer tests that were done at the C-Holes by  
7 having these two overviews up, one that gives us the  
8 geohydrologic cross-section at the C-Holes, and this helps to  
9 illustrate or to point out that most of the tests that have  
10 been done at the complex have been in the combination of the  
11 lower Bullfrog and upper Gram interval, which is a highly  
12 conductive zone.

13 There is a plan, and we are in the process of  
14 starting to implement it, of doing hydraulic and tracer  
15 testing at the Prow Pass interval, which is a low flow zone  
16 higher up in the interval, and I'll talk about that a little  
17 bit later on.

18 Another thing this illustrates is that there are  
19 faults intersecting the bottom of the C-Holes complex, and  
20 that is the reason why there are also some proposed studies  
21 of the hydraulic and transport properties of the fault zone  
22 that intersects the bottom of the C-Holes.

23 You have in your handouts following this overhead,  
24 you have a list of bullets that I will not show here, but  
25 I'll talk about those. Essentially, I'll talk about them by

1 looking at this triangle here and say that the test that  
2 you're looking at there, all the hydraulic and tracer tests  
3 listed were done with this well, C-3, being the pumping well  
4 in terms of hydraulic tests. In May of '95, this well was  
5 pumped and both C-2 and C-1 were in open condition. The  
6 packers were uninflated and we got hydraulic characteristics  
7 of the combined interval, the combined saturated interval at  
8 the C-Holes.

9           Then in June of '95, we inflated the packers in C-2  
10 and C-1, still pumping C-3, and that enabled us to get  
11 hydraulic parameters of individual intervals tested. Even  
12 though we were pumping from this interval here, we got  
13 responses in the Calico Hills and Prow Pass and the Tram and  
14 all of them, so we were able to obtain hydraulic parameters  
15 of those intervals.

16           And then from May of '96, all the way until  
17 November of '97, we conducted a very long hydraulic test,  
18 again with pumping C-3, and that long-term hydraulic test is  
19 the one that affected the far away wells that I mentioned.  
20 And the hydraulic test was the basis over which were  
21 overlaying a series of tracer tests that we'll be telling you  
22 about.

23           The first of those tracer tests was one in which we  
24 injected iodide as a conservative tracer from C-2, again  
25 pumping C-3. That was in February of '96. And then in

1 January of '97, we conducted another conservative tracer test  
2 in which again C-3 was being pumped, while 2-6 difluobenzoic  
3 acid was injected in C-2, and pyridone was injected in C-1.  
4 These are tracer tests that I will be talking about later on  
5 in the talk.

6           So like I said, the next overview, I will not show.  
7 You have it in your handouts.

8           This handout that you have essentially has a  
9 summary of all the tests. This is the May 22 test, the June  
10 12, the February, '96 test, which is a tracer test overlaid  
11 over a hydraulic test, and this is the long-term test. I  
12 want to point out here that although it says that the stop  
13 pumping is March 26th, it actually was pumped all the way to  
14 November of '97. This date indicates the end date for which  
15 the data were analyzed. That's what that means. But  
16 essentially here, this just gives you an overview of the  
17 tests.

18           And then in the overhead following that, I have  
19 some results of hydraulic properties at the C-Holes and at  
20 the distant wells. ONC-1 is one of the Nye County wells, and  
21 then there is H-4, WT-14, WT-3 and the combined rocks.

22           Maybe I can put this back up here while recapping  
23 these to point out that--no, that's not the one I intended to  
24 put up. It was the geohydrologic one that shows the aerial  
25 location of the wells that I thought could help us talk about

1 them.

2           So basically, ONC-1 is very close to the C-Holes  
3 that are not shown here. H-4 is up Antler Wash here. WT-14  
4 is at the top of Fran Ridge. WT-3 is down here at the bottom  
5 of Fran Ridge near Busted Butte. And the other numbers are  
6 for the combined interval at the C-Holes.

7           Now, the hydraulic results essentially indicate  
8 that we have a cone of depression that is elongated in a  
9 northwest, southeast direction. These are two snapshots, one  
10 at 30,000 minutes, which is 20 days. The other one is  
11 essentially at 321 days. And in both cases, you have  
12 information in terms of the well number, as identified here,  
13 a slash, with the dry-down indicated in centimeters.

14           Now, the cone of depression we feel is elongated in  
15 that northwest, southeast direction because of alignment with  
16 a series of fractures along and faults along Antler Wash.

17           All of the distant wells from the C-Holes were  
18 plotted on a drawdown versus  $t$  over  $r$  squared for all of  
19 those wells. And, you know, interestingly, they all kind of  
20 overlay each other and give credence to the fact that the  
21 whole area, the whole area that extends all the way to WT-3  
22 can be analyzed as a combined single saturated zone aquifer.

23           Starting to talk about the tracer testing, these  
24 are three conservative tracer tests. The first one in black  
25 is the iodide tracer test from injection into C-2, and the

1 right one is the PFBA injection into C-2 also. And these  
2 were both done by the USGS without recirculation of the  
3 tracer of the pumped water from the pumped well, and this was  
4 a tracer test that was done by Los Alamos Labs in preparation  
5 for their reactive tracer tests in which they had it in  
6 recirculation mode so it arrives earlier. But as you can  
7 see, apart from the earlier arrival, essentially all of them  
8 confirm the same shape of the tracer test, or the break-  
9 through curve of a conservative tracer going through the  
10 rocks at the C-Holes.

11           Here is an analysis of the February, '96 iodide  
12 tracer test in which we applied an analytic solution of  
13 advective dispersion equation by Alan Moench, and that  
14 particular analytic solution gives us a dispersivity value, a  
15 flow porosity and a storage porosity value.

16           In addition to that--so this is the line  
17 essentially that has, of course the jagged line is the data,  
18 and what we did was we did a hand fit using that analytic  
19 solution of Alan Moench's and obtained porosities and  
20 dispersivity. But in addition to that, we developed a  
21 parameter estimation routine to identify or to quantify the  
22 uncertainty in the data, and this parameter estimation  
23 routine was implemented in conjunction with this analytic  
24 solution of Alan Moench's of advection dispersion equation.  
25 And what we did was we took a hand solution and then

1 perturbed it, and the parameter estimation routine converges  
2 to a solution, and the advantage of that is it gives us, in  
3 addition to the parameters, it gives us a 95 per cent  
4 confidence interval, and we did that because we were trying  
5 to get at the concept of quantifying the uncertainty in the  
6 parameters.

7           In this particular case, we have a longitudinal  
8 dispersivity value of two and a half meters, a flow porosity  
9 value of 8.6 per cent, and a porosity, a storage porosity of  
10 16.3 per cent. Similarly, we did the same thing for the DFBA  
11 test. Again the same thing, applying that analytic solution  
12 and then using the parameter estimation routine for those two  
13 tests.

14           Now, I'd like to put back that triangle real quick  
15 here if I can find it. We're getting two overheads, and it's  
16 an advantage and a disadvantage at the same time. You have  
17 to be very coordinated.

18           After the tracer test that I just described, all of  
19 the ones that I just described, the tracers were injected in  
20 C-2, and the pumped well was C-3. This particular tracer  
21 test is a result of injecting Pyridone up there at C-1 and  
22 pumping at C-3, and this particular test took a long time,  
23 300 days, and we did not reach a peak and we got poor  
24 recovery, but at the same time, we feel that it still has  
25 quite a bit of value in terms of the initial arrival time.

1 And if we make a guess as to whether, you know, we are at the  
2 peak or not, we can come up with some numbers for the  
3 dispersivity values. But these are very iffy as a result of  
4 the fact that we don't know where we are.

5           For example, if we were to take the data from only  
6 the first 200 days of the test, it would appear that we had a  
7 curvature, and we could match it like that. But then when we  
8 took the whole data set up to the point that we arrived at,  
9 then a different set of numbers were obtained. So at this  
10 point, we really--well, the judgment as to what it indicates  
11 in terms of dispersivity and matrix diffusion parameters is  
12 ambiguous, but I think it will give us a fairly defensible  
13 value for the porosities, because they are to a large extent  
14 influenced by the arrival time. And of course the shape of  
15 the rising curve is influenced a lot by the Peclet number,  
16 which the dispersivity is a part of.

17           And so at any rate, this test has not been analyzed  
18 formally in a milestone yet, but there will be a level four  
19 milestone probably at the end of the year that we're going to  
20 try to add to the system that really doesn't exist at this  
21 point.

22           This is a summary of results from the conservative  
23 tracer test. The three that I first showed on one plot  
24 produced these numbers here of dispersivity values, flow  
25 porosity values and storage porosity values. And this is the

1 pyridone test that I showed at the end that is from a distant  
2 well, C-1, and this is the one that has not been analyzed  
3 formally yet. And also I'd like to point out that this  
4 number here can be ignored because this particular test so  
5 far has been analyzed assuming a single porosity medium, not  
6 a dual porosity medium. And so, therefore, values of matrix  
7 or storage porosity are--these could be ignored at the bottom  
8 right corner.

9           Essentially, we feel that the results of the C-  
10 Holes, tentative results from the C-1 well taken into account  
11 also, indicate that the relationship between dispersivity and  
12 scale as presented here, for example from Gelhar and others  
13 in 1992 with only a few points selected that indicate  
14 fractured rocks as opposed to other kinds of media, we feel  
15 that the C-wells at the distance of C-2 and at the distance  
16 of C-1 are consistent with these dispersivity versus scale  
17 relationships.

18           Future testing plan are to go up to the Prow Pass  
19 interval, the low flow zone, that will give a range of  
20 parameters not only for highly conductive zones, and it's  
21 also one of the first zones to be reached by radionuclides  
22 from a breached repository. We have to build special  
23 equipment for that, and we're working on that now.

24           The hydraulic testing in the fault zone has been  
25 proposed, and it's deferred for now for budget reasons, but

1 it's planned in the future, and also conducting hydraulic and  
2 tracer testing at other locations will probably be through  
3 the second tracer complex which Paul Reimus will tell you  
4 about.

5           Very quickly here, I'd say that the equipment  
6 redesigned for the Prow Pass testing conceptually and mainly  
7 involves the fact that we're going to be pumping water out of  
8 the zone, out of injection zone, being able to sample it at  
9 the surface, cool it and inject it back in in this concentric  
10 fashion, the idea being that if you look at the interval  
11 being pumped here, you can take the water in the central  
12 portion here all the way to the surface, around that central  
13 part pipe, and then reinject it back in. That way, we will  
14 be mixing the tracer in the injection zone, so there wouldn't  
15 be any issues about the tracer being only in one portion of  
16 the injection zone. It will be mixed throughout the zone,  
17 and at the same time, it would enable us to sample at the  
18 surface.

19           That is it. And I was going to ask for the  
20 questions for both of us, for myself and Paul, to be combined  
21 together. So, Paul, if you'd come over, you can continue.

22           PARIZEK: While paul is coming over, for lunch, there  
23 will be beef tips over noodles with lasagna. Buffet will  
24 cost \$5.00, and it will be served downstairs for lunch.

25           REIMUS: Thank you, M.J.

1           Well, let me begin by summarizing the results of  
2 the tracer test that Los Alamos conducted beginning in  
3 October of 1996, which involved the simultaneous injection of  
4 the four tracers whose curves you see on this plot here, and  
5 whose properties are summarized in the table at the bottom of  
6 this viewgraph over here.

7           I believe the Board was presented the preliminary  
8 results of this test last year, so I won't go into a lot of  
9 detail. And since then, we've added several thousand hours  
10 to the testoration, but that only amounts to about an inch  
11 here on the viewgraph, so it doesn't look terribly impressive  
12 on a log scale.

13           I want to point out a few key features of the test.  
14 First of all, you note the double peak behavior. We  
15 attribute that to multiple flow pathways in the roughly 300  
16 foot long interval that was tested, and this is a combination  
17 of lower and central Bullfrog tuft from C-2 to C-3 with  
18 partial recirculation.

19           A few key points to mention. The difference in the  
20 peak concentrations of the pentafluorobenzoic acid and bromide,  
21 which are two conservative tracers that have different  
22 diffusion coefficients, we attribute, and it's very  
23 consistent with matrix diffusion, it doesn't look like a  
24 significant difference here on the log scale, but that is  
25 about a 15 to 20 per cent difference in their peak

1 concentration, and this is to be expected because  
2 pentafluorobenzoic acid has roughly the effect of three lower  
3 diffusion coefficient than bromide and, therefore, does not  
4 diffuse as readily out of fractures and into the matrix as  
5 the bromide does.

6           Lithium, which is a weakly sorbing by ion exchange  
7 cation is attenuated relative to the conservative tracers due  
8 to sorption. The attenuation appears as a lower peak  
9 concentration in this first peak, and a lower and delayed  
10 peak in the second peak. This is consistent with sorption in  
11 the matrix and also sorption probably in fracture flow  
12 pathways in the second peak.

13           And, finally, the microspheres of 360 nanometer  
14 diameter polystyrene spheres that serve as surrogates for  
15 sub-micron size colloids moving through the saturated zone,  
16 and we see that their response is significantly attenuated  
17 relative to the solutes, but however, a significant fraction  
18 of them do arrive even earlier than the solutes, and they  
19 persist throughout the test.

20           We interpreted this test using a dual porosity  
21 conceptual model that's implemented very similar to the Al  
22 Moench model that M. J. mentioned, and I want to emphasize  
23 that these break-through curves were all simultaneously  
24 fitted, that is, we constrained the interpretation such that  
25 the flow parameters, in other words, residence time,

1 dispersivities and mass transfer coefficients for matrix  
2 diffusion for all three tracers had to be the same in each  
3 flow pathway since they were all injected simultaneously and  
4 should have followed the same flow pathways. And by doing  
5 that, the model accounting for differences in the response of  
6 the tracers gives us parameter estimates for matrix diffusion  
7 and sorption of the lithium.

8           And I won't go into all the details in this table  
9 here, but this summarizes all the transport parameters, the  
10 flow and transport parameters that are deduced from the test.  
11 And basically the two halves of the table here are two  
12 different ways of treating the lithium behavior. Either it's  
13 equilibrium sorption or rate limited sorption.

14           The important point is we get estimates of  
15 dispersivity presented here as Peclet number in various  
16 pathways through the system. The two pathways here basically  
17 account for the two peaks that were observed in the tracer  
18 responses. This is a mass transfer coefficient for matrix  
19 diffusion. We get an effective flow porosity, which is  
20 derived from the mean residence times of the tracer through  
21 the system, and also estimates of the sorption parameters for  
22 lithium.

23           And I want to point out that the sorption  
24 parameters deduced for the lithium are quite consistent with  
25 parameters derived from laboratory scale testing, and in fact

1 if anything, there was more sorption apparently occurring in  
2 the field experience than will be deduced from laboratory  
3 experiments.

4           And we feel this is important because it shows that  
5 the laboratory measurements are providing first a good  
6 indication of sorption at field scale, or at least a scaling  
7 that we can understand, and secondly, if anything, we're over  
8 estimating--or I should say under estimating and being  
9 conservative in applying laboratory scale sorption parameters  
10 to field scales. And this is important because we can't test  
11 radionuclide transport in the field and, therefore, we have  
12 to rely on laboratory derived sorption parameters for  
13 radionuclides to predict field scale transport.

14           Very quickly, I've got a quad very similar to what  
15 M.J. had showing ranges of dispersivities. These are  
16 longitudinal dispersivities from our test, superimposed on  
17 the plot taken from a paper by Shlomo Neuman in Water  
18 Resources and Research from 1990, plotting a variety of data  
19 from tracer tests at different length scales and also  
20 numerical modeling results. And you see that the  
21 dispersivities we get out of the tests more or less fall  
22 within the 95 per cent confidence intervals that Shlomo  
23 identified in his paper.

24           Okay, now I'll shift gears somewhat and talk about  
25 some laboratory experiments we've done to try to better

1 constrain the interpretation of our tracer test and  
2 ultimately reduce uncertainties in the parameters obtained  
3 from the tracer test.

4           One of the things we're doing is attempting to  
5 measure diffusion coefficients of the tracers that we used in  
6 the field test in a laboratory experiment, and the experiment  
7 apparatus is shown here called a diffusion cell system. We  
8 basically separate a large reservoir containing high  
9 concentrations of the tracers of interest from a smaller  
10 reservoir that's initially tracer free with a block of intact  
11 matrix material of known dimensions.

12           This reservoir is continuously stirred and  
13 continuously flushed to a fraction collector, and we  
14 essential attain a break-through curve of tracer diffusing  
15 through the rock.

16           And example of some of the data is shown here for  
17 Central Bullfrog Tuff. You see resulting break-through  
18 curves for bromide and pentafluobenzoic acid, and also model  
19 fits to the data. I want to point out that this  
20 discontinuity in the fitting is due to changes in the flow  
21 rate through the outlet collection chamber, which caused  
22 these changes in slope and discontinuities.

23           The important point is we can back out from this  
24 simple one dimensional numerical modeling diffusion  
25 coefficients through the block of matrix material, and we've

1 done this for both Central and Lower Bullfrog Tuff. And  
2 there's a couple important points here. First of all, we see  
3 there is about a factor of two to three difference between  
4 the Lower and Central Bullfrog Tuff diffusion coefficients  
5 for both conservative tracers, and the higher diffusion  
6 occurring in the Lower Bullfrog Tuff.

7           This is not difficult to understand. When you look  
8 at the porosities of the specimens, the Lower Bullfrog Tuff  
9 had a much higher porosity, so the diffusion coefficient  
10 seems to correlate with porosity.

11           We also know that there is roughly a factor of  
12 three difference in both tuffs between the bromide and  
13 pentafluorobenzoic acid diffusion coefficients. This is  
14 important because when we initially did our interpretation of  
15 the field data, we assumed a factor of two difference based  
16 on literature values. It appears that based on these  
17 experiments, it's really more like a factor of three  
18 difference, which will have somewhat of an effect, relatively  
19 minor effect probably, but nevertheless, an effect on the  
20 interpretation of the test.

21           Okay, another thing that we've done recently that  
22 has not previously been reported is interpret the microsphere  
23 response from our combined tracer test. This is a rather  
24 involved exercise that I won't get into the details on, but  
25 essentially we have a number of--what I've done is apportion

1 the mass of microspheres to different sets of pathways that  
2 have different filtration parameters. This is a simple model  
3 that's shown here in its mathematical form on this viewgraph  
4 that involves a linear forward filtration rate, and a linear  
5 resuspension rate.

6           What I found is that you couldn't explain the  
7 microsphere response in each of these peaks with a single  
8 filtration and resuspension rate so, therefore, the mass is  
9 split up into pathways that have different rates. And the  
10 results are summarized here, and this is certainly not a  
11 unique fitting exercise or a unique interpretation, but  
12 nevertheless, we are providing some parameters, or at least a  
13 range of parameters, that performance assessment can use for  
14 colloid transport through the saturated zone.

15           Future work, very briefly. M.J. mentioned the Prow  
16 Pass test. We want to and plan to conduct a test very  
17 similar to the test that was conducted in the Bullfrog Tuff,  
18 which would involve multiple tracers. This time, we would  
19 like to use three different sizes of microspheres to better  
20 constrain the microsphere interpretation and hopefully get  
21 some more meaningful colloid transport parameters for  
22 performance assessment.

23           We want to complete sorption and diffusion cell  
24 tests in Prow Pass Tuffs. These were initiated last fiscal  
25 year and are ongoing right now. I haven't talked about the

1 sorption tests, but we are measuring lithium sorption to the  
2 Prow Pass tuffs that are going to be in the interval tested.

3           We want to go back and reinterpret the Bullfrog  
4 test results using some of the information derived from the  
5 diffusion cell test. And this should say Paintbrush Canyon,  
6 but M. J. mentioned the Paintbrush Canyon fault zone testing  
7 that's been deferred to FY-1999.

8           Okay, finally, I want to talk very briefly about an  
9 activity that was just started this fiscal year which  
10 involves Los Alamos, USGS and Lawrence Berkeley Laboratory  
11 staff to recommend a site for a second testing complex at  
12 which hydraulic and tracer tests could be conducted for the  
13 project. At this point, we're hoping to complete this  
14 activity actually within the next few weeks, and provide a  
15 recommendation to the project and then basically wait for  
16 comments and response from the project on that.

17           The group that's convened, or the group that's  
18 doing this activity has currently more or less converged on  
19 recommending a location right in the immediate vicinity of  
20 SD-6, which is up on Yucca Crest, and as you can see, within  
21 the repository block itself, or actually we'd be testing  
22 beneath the repository block. There are several reasons  
23 we've come up with this preliminary recommendation.

24           First of all, this would involve testing relatively  
25 unfaulted rock, which is in contrast to the setting, the

1 geologic and hydrogeologic setting at the C-Wells and several  
2 other locations that have been proposed. Also, it's  
3 obviously relevant to the project, in that we'd be testing  
4 saturated zone directly beneath the repository block where  
5 radionuclides will first encounter the saturated zone.

6           Also, there's a number of existing wells, H-3  
7 through 6 that I've shown here, and there's others that I  
8 haven't shown, that could be used as observation wells to get  
9 hydraulic responses, long-term hydraulic responses all across  
10 the block.

11           Another aspect of this proposal is to locate a  
12 couple of wells, which I haven't shown here, somewhere in  
13 Solitario Canyon, probably within a kilometer of the SD-6  
14 cluster, and these wells would be intended to investigate the  
15 hydraulic and transport properties of the Solitario Canyon  
16 Fault, which is of interest since the Solitario Canyon Fault  
17 appears to be some sort of a pounding fault, in that there's  
18 a significant head gradient to the west of the fault, and  
19 basically a very flat gradient to the east of the fault, and  
20 responses over those kilometer distance can certainly be  
21 looked for when pumping one location or the other at the  
22 other location.

23           With that, I'll wrap up and take questions for both  
24 M.J. and I, I guess.

25           PARIZEK: Thank you. Questions from the Board?

1           Parizek, Board. There's a question about the next test  
2 that you run. Will you run that more than 200 days so you  
3 can actually get the break-over or the peak? It's  
4 unfortunate in a way that you really didn't get the peak on  
5 the past test. That's kind of vital data. So now the  
6 question is how many days would you have to go with a new  
7 test? Is it planned that you'll keep going until you finally  
8 get that peak?

9           REIMUS: Are you talking about the Prow Pass test?

10          PARIZEK: Right.

11          REIMUS: That certainly would be the hope. Maybe I  
12 should let M.J. address that since that was really a USGS  
13 test. But we do have a number of constraints that are placed  
14 on us that sometimes, you know, we can't test optimally, and  
15 there are schedules to meet and so forth. So I guess the  
16 answer is yes, we would definitely want to go well past any  
17 peaks in any subsequent tests. That's always subject to  
18 constraints that the project has as far as schedule and money  
19 and so forth.

20          PARIZEK: One other question about the spheres arriving  
21 ahead of the solute. It's like a fisherman falls in a creek  
22 and he gets downstream before the muddy water he stirs up.

23                   Give us a little understanding of how that might be  
24 possible. I mean, obviously it suggests something about  
25 diffusion in the matrix or some other mechanism to slow down

1 solutes.

2 REIMUS: Sure. Yeah, you've definitely touched on my  
3 response. Basically, the spheres would be expected to be  
4 confined to fractures. They have a three order of magnitude  
5 lower diffusion coefficient than the solute tracers. They're  
6 much larger in size, so they might actually be physically  
7 excluded from the matrix. But essentially, communication  
8 with the matrix should be minimized, if not completely  
9 eliminated, for the spheres and they would tend to be, at  
10 least the early response would tend to be more indicative of  
11 true fracture flow only pathways.

12 PARIZEK: Go ahead.

13 COHON: Cohon, Board. I'll go first since mine builds  
14 directly on that.

15 Your multiple pathway model that is a way to  
16 explain the spheres, is there any physical--can you explain  
17 those five pathways specifically, or are those simply  
18 mathematical constructs to make it fit?

19 REIMUS: For the spheres?

20 COHON: Yes.

21 REIMUS: Yeah, those are basically mathematical  
22 constructs, and what I've done is really split up--  
23 essentially what's probably really the case is that there's a  
24 non-discrete distribution of filtration and resuspension  
25 parameters that describe the colloid transport behavior and

1 interactions with the fracture surfaces, and I've tried to  
2 capture that with discrete breakup basically of this  
3 continuous distribution in a way that at least matches the  
4 response of the microspheres. So I tried to do it as simply  
5 as possible with as few discrete packets of filtration and  
6 resuspension parameters.

7       PARIZEK: Alberto Sages?

8       SAGES: Sages, Board.

9               I like the diffusion cell apparatus. What is the  
10 size of the rock specimen?

11       REIMUS: The dimensions at this point of course are  
12 variable, but the rock wafers that we've tested so far, we  
13 call them wafers, are about a centimeter thick and about ten  
14 centimeters diameter, basically the diameter of the core from  
15 the C-Holes. I should point out these were, you know, cores  
16 taken directly from the interval that was tested.

17       SAGES: How do you select the specimen? Like what if  
18 it has a fracture running across it?

19       REIMUS: Yeah, we try to pick specimens that are  
20 representative of intact matrix, so we try to avoid any  
21 fractures or features that may affect the measurement.

22       SAGES: And what level of duplication or multiple  
23 specimens do you use to account for what no doubt would be  
24 significant variations in the transport across the specimen?

1 REIMUS: Currently just one. We would like to and have  
2 certainly proposed to do a number of these tests on the same  
3 material, varying thickness, varying surface area. You know,  
4 budget concerns basically keep us from doing everything we'd  
5 like to do.

6 SAGES: Thank you.

7 PARIZEK: Priscilla Nelson?

8 NELSON: Nelson, Board.

9 How long does one of these tests take? I mean, is  
10 this getting to a point where if you wanted to do a suite of  
11 these, it would be a fairly significant time investment right  
12 now?

13 REIMUS: You're talking about the diffusion cell test?

14 NELSON: Yes. It seemed like you had some with--

15 REIMUS: I can best answer that by looking at the  
16 response.

17 NELSON: --200 hours or 400 hours for the test,  
18 something like that?

19 REIMUS: I think that's right. I think it was on the  
20 order of 500 hours, if I can find it. You could probably  
21 look in your packet and find it faster than I can.

22 NELSON: I think it was--it seemed like it was on the  
23 order of like a month to do a test.

24 REIMUS: Right.

25 NELSON: And how many do you wish to do?

1 REIMUS: I'd like to do at least three to five on each  
2 matrix rock type of varying thickness and possibly surface  
3 area. I think thickness may be more important.

4 NELSON: So that sounds like you might have like two  
5 dozen tests, or something like that that you'd like to run?

6 REIMUS: Yes.

7 NELSON: And you have one cell? How many sells do you  
8 have?

9 REIMUS: Oh, no, we make as many cells as we need to do  
10 as many tests as we want.

11 PARIZEK: Other Board questions? Staff questions? Jeff  
12 Wong?

13 WONG: Jeff Wong, Board.

14 I have just a short question for M.J. On the  
15 pyridone tracer test, because your recovery is so low, the  
16 extrapolation as to what that curve is so you can then  
17 generate your parameters is really uncertain; that's what  
18 you're telling us?

19 UMARI: I think the recovery isn't as much of an issue  
20 in my mind, in that once you get some material between the  
21 two wells, then essentially you have a slug of material  
22 connecting the two wells, and the shape of the break-through  
23 curve is going to give you, if analyzed properly, the  
24 characteristics, transport characteristics of the medium,  
25 whether it's one gram that links the two wells or ten

1 kilograms.

2           So I don't think that is the issue as much as the  
3 clear definition of the peak, because essentially for  
4 conservative tracer tests, you're trying to determine flow  
5 and storage porosities and dispersivity values, and the  
6 rising shape of the curve at the beginning is influenced a  
7 lot by the dispersivity. So a lot of that is there, but  
8 there's going to be uncertainty because we haven't gotten to  
9 the peak proper, so we don't really--you know, there's going  
10 to be ambiguity about coming up with that parameter.

11           And also the final number for the porosities is  
12 also dependent on the actual existence of the peak. So those  
13 will have uncertainties because of that. But it's not  
14 because of the amount or mass recovered.

15           WONG: Okay, thanks.

16           PARIZEK: Other Board questions? Staff?

17           (No response.)

18           PARIZEK: Okay, the good news is we have coffee break,  
19 but the bad news is we're only going to allow five minutes.  
20 We're running behind and we have a lot of important papers to  
21 still hear before lunch. So let's try to get back here in  
22 five minutes.

23           (Whereupon, a brief break was taken.)

24           PARIZEK: Let's get organized here. The time is short  
25 between now and the lunch period. If we could reconvene? So

1 if you could bring your coffee on board?

2           The next talk will be given by John Czarnecki from  
3 the U. S. Geological Survey, who has been associated with the  
4 program for a number of years, and he'll talk on preliminary  
5 3-D finite-element ground-water flow model of the saturated  
6 zone at Yucca Mountain. John?

7           Could we have everybody's attention? We're  
8 beginning our next presenter.

9           CZARNECKI: Thank you for that introduction. It's a  
10 pleasure to be back in the Amargosa Valley. And thinking  
11 back to the time I came here first in 1983, I think this is  
12 the very first time I've worn a tie in the Amargosa Valley.

13           I noticed also that there are a number of new  
14 residents in the valley, namely the camels. And they also  
15 join various other forms of wildlife, ostriches up in the  
16 north end of the valley, and I'm wondering where Dr.  
17 Doolittle is with respect to all this.

18           That aside, I'd like to share with you some results  
19 from a preliminary model of the saturated zone at Yucca  
20 Mountain. Before I get into the details, I'd like to  
21 acknowledge my co-collaborators on this effort. Claudia  
22 Faunt from the USGS has been involved with building the  
23 hydrogeologic framework model which was used in the regional  
24 model, and was sampled at a finer scale, or at a scale  
25 pertinent to the site. Carl Gable from Los Alamos has been

1 involved in helping to take that stratigraphic hydrogeologic  
2 information and grid it into a form that we can use for  
3 numerical modeling, and George Zyvoloski, also from Los  
4 Alamos, has been involved with me in actually doing the  
5 numerical modeling.

6           I want to put up a slide that is not in your  
7 package just to show you the relation between the site model,  
8 which is this box, rectangular box, and the regional model  
9 that Frank D'Agnesse described earlier. It's embedded just  
10 about in the middle, and Yucca Mountain is in the northern  
11 half of the site model.

12           Why was that rectangular domain selected? Well, it  
13 was selected first and foremost to be coincident with the  
14 grid cells in the regional ground-water flow model such that  
15 the base of the site model was equivalent to the base of the  
16 regional model.

17           The second reason for selecting this domain is that  
18 it be sufficiently large to minimize the effects of flow and  
19 pressure boundary conditions on estimating permeability  
20 values at Yucca Mountain.

21           An additional reason for the domain's shape and  
22 size is that it be sufficiently large to be able to assess  
23 ground-water flow at distances 30 kilometers down gradient  
24 from the design repository area. Also, we wanted to make the  
25 domain small enough to minimize the number of computational

1 nodes used in the model.

2           Also, the domain was selected such that it be thick  
3 enough to include part of the regional Paleozoic carbonate  
4 aquifer, which is in the base of the model. And, finally,  
5 the domain is large enough to include well control in the  
6 Amargosa Desert at the southern end of the model.

7           This illustration shows the hydrogeologic units as  
8 would be met from the surface. The northern part of the area  
9 is dominated by volcanic units in and around Yucca Mountain.  
10 The yellow depicts basin fill alluvium and other basin  
11 sediments. These sediments are tertiary to quaternary in  
12 age. These units in brown and blue represent the Funeral  
13 Mountains which are in the northwest, quartzites, and then  
14 down in the south, carbonates. But the box shows that it's a  
15 fairly simple depiction at least from a map view.

16           Well control in the vicinity of the site model is  
17 shown on this slide. Again, the site model area depicted by  
18 this box. Notice, and we saw this in other talks, the number  
19 of wells in and around Yucca Mountain and in the Amargosa  
20 area. These form the basis for calibration. We try to use  
21 water level data from these wells in calibrating our flow  
22 model.

23           A little closer detail, this time the site model is  
24 the perimeter of this figure. Each of the points represent  
25 well control. The black lines represent the potentiometric

1 surface one could construct using water level data from these  
2 wells. Yucca Mountain again is in the northern half and it's  
3 in an area where we see a bunching together of these  
4 potentiometric surface lines.

5           I kept the contour interval uniform to emphasize  
6 this particular feature. It's referred to the large  
7 hydraulic gradient, and we have several possible explanations  
8 for this feature. It's not something that we haven't  
9 considered over the years. Some explanations include that  
10 the large hydraulic gradient was caused by faults that  
11 contain nontransmissive fault gouge or that juxtapose  
12 transmissive tuff against nontransmissive tuff.

13           Another explanation may be that a large hydraulic  
14 gradient shows a different type of lithology that is less  
15 subject to fracturing.

16           Another possible cause may be that we have a change  
17 in the direction of the regional stress field and a resultant  
18 change in the intensity, interconnectedness and orientation  
19 of open fractures on either side of the area with respect to  
20 the large hydraulic gradient.

21           Another explanation may be that what we're seeing  
22 at the large hydraulic gradient is an apparent gradient  
23 resulting from a disconnected, perched or semi-perched water  
24 body.

25           And, finally, another explanation we could invoke

1 is that a highly permeable buried fault drains water from the  
2 overlying tuff units into a deeper regional carbonate  
3 aquifer.

4           Now, what's attractive about each of these  
5 explanations is that they could be used to formulate various  
6 models that we can then test these hypotheses.

7           I've included this slide, which is a fence diagram  
8 of the various hydrogeologic units going from north to south  
9 and from west to east, and this results from a 1,500 meter  
10 sample spacing of the hydrogeologic framework model. It is  
11 perhaps less detailed than we would like to see, and we  
12 recognize that, and in our current revision of this model,  
13 we're going at a 250 to 500 meter sample spacing. But we  
14 took this particular sample distribution and used it to  
15 produce the finite-element grid, which I'm about to show you,  
16 which represents each of these three dimensional objects in  
17 tetrahedral finite elements.

18           The different colors represent the different  
19 material properties used in the model. We keep track of  
20 these with the numbers on the left side of the figure. The  
21 red represents alluvium. These yellow and green units  
22 represent volcanic units. And the darker blue represents I  
23 believe the lower carbonate aquifer. This dark blue  
24 represents a volcanic pluton, as I recall.

25           So in the model, we keep all of these units uniform

1 and in their properties. We haven't broken them down into  
2 variations within a given unit from north to south or across  
3 the model.

4           This slide shows the distribution of hydrogeologic  
5 unit permeability values. It shows the different units used  
6 within this model, and on the right-hand side, the values  
7 that were used in the model to obtain the best fit to  
8 hydraulic head.

9           In the middle, we have high and low values that  
10 were available to us from the literature to help us constrain  
11 values used in the model. Not every one of these values fits  
12 within the values shown between high and low values.

13           A good example of that is the lower carbonate  
14 aquifer where the value used in the model is about 4 darcies,  
15 four times ten to the minus twelve meters squared. I  
16 compared that with the literature value that we had, and  
17 these values probably represent numbers derived from core for  
18 that unit.

19           When we take the values of permeability using the  
20 model and look at them in three dimensions, this is the  
21 picture that emerges. We're going from red units, which are  
22 about 10 darcies, to the blue units, which are ten to the  
23 minus 18 meters squared, a microdarcy. So we have quite a  
24 range in permeability.

25           One feature that was used in the model which is not

1 a hydrogeologic unit is this zone shown as a blue plane.  
2 That plane was added to the model to represent the large  
3 hydraulic gradient. We could not represent it accurately  
4 without inclusion of this additional zone.

5           There's another zone that you can barely see. It's  
6 a green, slightly higher permeability. That's Solitario  
7 Canyon, and that was added to the model.

8           Now, if we look at these permeability units in  
9 fence diagram, we get this distribution. Now, the large  
10 permeabilities in the model show up in the bottom. We have  
11 the lower carbonate aquifer which is about 4 darcies, and the  
12 volcanic units here around Yucca Mountain are about a  
13 hundredth of a darcy to a tenth of a darcy. This blue line  
14 represents a barrier to north-south flow across the large  
15 hydraulic gradient.

16           These zones are shown again in map view. The black  
17 diamonds represent the Solitario Canyon barrier and the black  
18 crosses represent the east-west barrier across the large  
19 hydraulic gradient. These open circles represent nodes that  
20 were used to specify recharge at Forty Mile Wash.

21           What one can do with a model of this sort, and any  
22 model that one produces, is to take each of the potential  
23 parameters and vary them so that we see how the model  
24 responds to each of the individual parameters. And I've done  
25 that in this slide, and we have a ranking of the individual

1 parameters, and I've got them named here. The top three, the  
2 first one is the Forty Mile Wash recharge, in part because  
3 where we're specifying that recharge is in a wash where we  
4 have an observation node, so naturally when you increase the  
5 recharge, you're going to see the impact at that observation  
6 node. But it's quite dramatic.

7           The next one is the Solitario Canyon Fault zone,  
8 and the third one is the middle volcanic aquifer, also known  
9 as the Crater Flat Tuff. So what one can do with a list of  
10 this sort is to prioritize where one should go to the field  
11 or emphasize resolution of the model.

12           I need to emphasize that this list is non-unique.  
13 It's highly non-linear. Any changes in the model likely will  
14 result in a different order of ranking for any one of these  
15 parameters.

16           The simulated hydraulic head and residuals are  
17 shown on this slide. The colored region shows the  
18 potentiometric surface going from highs of around 1,200  
19 meters, to lows of about 600 meters down in the Amargosa  
20 Valley. Each of the symbols represents a range that the  
21 observed and calculated hydraulic head fall into. And by and  
22 large, around Yucca Mountain, we're going from about plus 5  
23 to minus 15 in matching the hydraulic head.

24           We'll get a little better representation of that in  
25 this slide if we plot simulated hydraulic head against

1 measured hydraulic head, we see a reasonably good fit for  
2 this particular model. There are a few busts at this point  
3 in particular where we have difficulty representing some of  
4 the points in the vicinity of the large hydraulic gradient.

5           The correlation coefficient is quite high for this  
6 particular model, perhaps in part because of the range that  
7 the data span. We have a .97 or .98 correlation coefficient.  
8 If we looked strictly at the area around Yucca Mountain,  
9 that number decreases to about .84, indicating that we can do  
10 a little better job there.

11           A histogram of these residuals shows that points  
12 are well distributed about zero. How did we come up with  
13 such a good fit? Well, we didn't do this strictly by hand.  
14 We used an automated parameter estimation scheme which can be  
15 used with any model, and it eliminates some of the bias that  
16 one might have, or might occur if one were to do this  
17 calibration by hand. Again, some of the outliers are shown  
18 here, this roughly 100 meter discrepancy occurs in the area  
19 of a large hydraulic gradient.

20           The model is also useful in that it can tell you  
21 graphically what the direction of ground-water flow within  
22 the model is. This is a plane which slices horizontally  
23 through the model, and each of these vectors represents the  
24 direction of ground-water flow.

25           Let me stress that each of these vectors is uniform

1 in length to its neighbor. They're normalized, and the  
2 colors depict the different magnitudes of the flow. If one  
3 were to non-normalize this, which I didn't bring, the vectors  
4 in this area are quite small.

5 I'm going to close with a final slide indicating  
6 the limitations of the model as it stands. We recognized  
7 that the model discretization is coarse, and as a result,  
8 causes incomplete definition of the hydrogeologic units.

9 Secondly, the permeability is known to vary  
10 spatially within individual hydrogeologic units.

11 Also, an average temperature for the entire  
12 saturated zone contained within the site model has not been  
13 calculated. One of the sensitivity analyses that I did was  
14 to look at the effect on flow as a result of changing  
15 temperature.

16 Also, the hydraulic head conditions that were used  
17 to specify boundaries for this particular model are based on  
18 a process of extrapolation and interpolation of the extant  
19 potentiometric data.

20 We make a steady-state assumption which may be  
21 invalid in areas in which ground-water withdrawals are  
22 occurring, particularly in the Amargosa Desert.

23 Also, the no flow specification along the base of  
24 the model is likely inappropriate, but because of the need to  
25 get this model out, we took an expedient route.

1           Finally, the representation of the large hydraulic  
2 gradient remains inconclusive. And I mentioned that we can  
3 test various models of the gradient. That was done, and I  
4 can elaborate during the question period if there's an  
5 interest there.

6           PARIZEK: Thank you, John. Board questions? Debra  
7 Knopman?

8           KNOPMAN: Knopman, Board.

9           Two questions. One, I apologize for coming in late  
10 on your presentation, but I'm wondering if you could go over  
11 a little bit more in a more--in some detail about how your  
12 model is consistent with the regional flow model in terms of  
13 its visualization of the flow regime? That's question number  
14 one.

15           And question number two has to do with the  
16 consistency factor between your model and your  
17 conceptualization of flow and M.J. Umari's conception of flow  
18 and the kinds of parameters they're backing out to describe  
19 that flow relative to your model.

20           CZARNECKI: Two excellent questions. The connection  
21 between the regional and site models is such that we've  
22 compared fluxes from the site model with those of the region.  
23 Not everywhere did the fluxes agree. The idea behind taking  
24 the domain that we selected was so that we could take fluxes  
25 from the regional model, and this is still the plan, to map

1 those fluxes onto the boundaries as they occur and specify at  
2 least on one side, and maybe other sides, where those fluxes  
3 occur.

4           We recognize that there are disconnects because of  
5 the boundary conditions that we impose, and we're working to  
6 improve those.

7           Regarding the permeability distribution, we have in  
8 the model, particularly for the Crater Flat Tuff and the  
9 tests at the C-Holes, it has been suggested, and I agree with  
10 these suggestions, that we look at larger values of  
11 permeability in the Crater Flat Tuff and try to pin those  
12 values within the site model and calibrate the model without  
13 changing those parameters. That's something we can pursue.  
14 That was not done.

15         PARIZEK: Chairman Cohon?

16         COHON: Cohon, Board.

17           You offered several possible ways to explain the  
18 large hydraulic gradient, and then you tell us how you  
19 treated it in the model. Is there any correspondence at all  
20 between that model treatment and any of those possible  
21 causes?

22         CZARNECKI: Yes. The current model, the one that gave  
23 us the best fit where we impose a barrier to flow, might be  
24 considered as a fault zone which juxtaposes transmissive or  
25 nontransmissive units, or has fault gouge. It's a barrier to

1 the flow.

2           One other model that we tested that did not hold up  
3 was to treat that zone as a drain in which water flows  
4 downward down the drain, and out through the carbonate units.  
5 But the heads on the upgradient side cannot be sustained.

6           COHON: Are we doing any field tests to substantiate the  
7 current treatment in the model?

8           CZARNECKI: Not the current treatment per se, but the  
9 work at WT-24 is encouraging because it's looking at the  
10 potential mechanism behind the large hydraulic gradient. As  
11 Zell Peterman pointed out, the initial indications show that  
12 the sampled water may be that of a perched zone. Now, that's  
13 a very preliminary analysis. Also, the configuration of the  
14 hole is such that we're only seeing the upper part of the  
15 saturated zone, and I am very eager to find out what happens  
16 as we continue drilling and test lower parts of that part of  
17 the mountain.

18           COHON: Thank you.

19           PARIZEK: Paul Craig?

20           CRAIG: Craig, Board.

21           This morning, we heard that the lifetime of the  
22 water might be 5,000 years, and if the retardation time is a  
23 factor of two, that brings us to 10,000. If the retardation  
24 is a factor of 20, that brings--that may make the saturated  
25 zone the most important hole up in the whole system. But

1 there's the problem of cracks. So the question for you is  
2 what fraction of the water is going to go through the cracks  
3 and possibly be fast paths? And how do you build that issue  
4 into your model?

5 CZARNECKI: In this particular model, we assume that the  
6 permeabilities represent a bulk rock matrix combination, or  
7 an effective continuum. If one were to think of flow through  
8 fractures only, one has to think about much faster flow than  
9 a combination of matrix and fractures. The permeability is  
10 one story. Porosity is the other component. And then in  
11 terms of velocities, the porosities for the fracture system  
12 are much, much smaller, translating into much faster  
13 velocities.

14 I did a calculation years back using a much simpler  
15 two dimensional model, and at that time, I had to estimate  
16 what the potential range in porosity might be, and I think  
17 we've done a little better at Yucca Mountain in terms of  
18 coming to a bracketed value for porosity. I think now we're  
19 within, oh, I'd say at most, two orders of magnitude.  
20 Certainly for the C-Holes much less than that, probably  
21 within an order of magnitude.

22 But at the time I did the velocity calculation, I  
23 was out to about three orders of magnitude, which gives a  
24 very big spread in terms of the potential travel time from  
25 the repository out to the accessible environment.

1 I don't know if I answered your question.

2 CRAIG: I remain confused on how to think about this.  
3 What fraction, let me phrase it differently, what fraction of  
4 the water do you think might go through fast paths?

5 CZARNECKI: Let me add. Yucca Mountain, my conceptual  
6 model is that fractures dominate flow at Yucca Mountain. I  
7 don't think I'll get any argument there. In terms of ground-  
8 water flow, if you want to drill a well, you're going to  
9 produce water in the fractures. If you don't hit  
10 transmissive fractures, you won't nick water.

11 PARIZEK: Parizek, Board.

12 Do you plan any transient studies in this site  
13 scale model?

14 CZARNECKI: I didn't put up the slide that we have  
15 planned work. Transient analyses would be useful, as Lynn  
16 Gelhar has advocated, in using the fluxes from hydraulic  
17 tests, and using those to constrain values from hydraulic  
18 tests. Other than that, probably not.

19 What we would like to do is take a different data  
20 set, completely different. I failed to even give the  
21 preamble of what code we're using and what it feeds. Bruce  
22 Robinson is going to talk about transport simulations, which  
23 have to use transient analysis. And the code that I'm using  
24 is passed directly to Los Alamos so that they can do  
25 transport. So there's a transient component there. We want

1 to take advantage of temperature data, which is an additional  
2 independent constraint which can be simulated using this  
3 current code and the grid.

4         PARIZEK: Parizek, Board.

5                 Last night, you raised a question about the study  
6 plan and where these are up in the dusty attic of the  
7 program. What elements would you put in from the old study  
8 plan that you think ought to be put in in order to do  
9 additional work of the type you're doing here with the site  
10 scale model, or for that matter, how we link it in with the  
11 regional model?

12         CZARNECKI: We have very little data up gradient of  
13 Yucca Mountain. We have begged, borrowed and steal data from  
14 the other work at the test site. Any time there's a new hole  
15 at the test site, we try to use that data in any of our work  
16 outside of Yucca Mountain. It's very clear to me that we  
17 need additional control on the up gradient side. It has been  
18 suggested, perhaps rightly or wrongly, that the large  
19 hydraulic gradient has no impact on flow down gradient from  
20 it. I disagree. I think that because of the uncertainty in  
21 permeability associated with units at Yucca Mountain,  
22 depending on how you construct the large hydraulic gradient  
23 will result in a different order of magnitude, or different  
24 rate of flow on the down gradient side of Yucca Mountain.

25         PARIZEK: The report earlier on the C-Well complex high

1 porosities that were mentioned, are they reasonable? And if  
2 you were to do a transient model, you've got to do something  
3 obviously with the storage properties. These are high  
4 numbers. Are they physically possible for the rocks that  
5 were being tested?

6 CZARNECKI: I think M.J. Umari would like to comment on  
7 that, and I will defer the question to him.

8 UMARI: Can I, please? Because that was something I  
9 should have made clear in my presentation. The numbers that  
10 we have for flow porosity are not fracture porosities. We  
11 are conceptualizing a medium in which the primary flow path  
12 is in fractures and segments of matrix connecting  
13 discontinuous fractures. And then there is a storage portion  
14 of the matrix that just functions as storage. But the dual  
15 porosity conceptualization that we have is a medium in which  
16 there's a primary flow advection, you know, transport by  
17 advection in fractures, plus segments of matrix connecting  
18 discontinuous fractures. Okay? And then there's a storage  
19 portion which is in some dead spaces and portions of the  
20 matrix.

21 So when you see a 30 per cent, I'm not saying that  
22 the fracture porosity is 30 per cent. Fracture porosity  
23 cannot go more than probably 3 per cent. So those numbers  
24 are for a combination of fractures and portions of the matrix  
25 that contribute to the main flow in order to do a porosity

1 conceptualization.

2       PARIZEK: Paul Craig?

3       CRAIG: Sorry to come in with a second one, but I think  
4 something important is going on here.

5                You just told us, John, that you think that  
6 fractures may be most of the flow. If in fact that's true,  
7 the fast path is the slow path, is the dominant path. If  
8 that's the case, so we've got big cracks through fast paths,  
9 plus hold-up someplace in whatever reservoirs are there,  
10 that's the model that Umari is talking about, if that's the  
11 case, then a conservative viewpoint, which is the fast path  
12 dominates viewpoint, gives you long hold-up times. That's  
13 really good news for the repository, and that's not a picture  
14 I've heard before. The picture we've heard before is the  
15 fast paths are a big problem. With your information, the  
16 fast paths make it a small problem, and that's really good  
17 news. Now, what's wrong with that picture? Am I missing  
18 something?

19       CZARNECKI: I'll have to think about that.

20       CRAIG: It seems to me that everything we've heard today  
21 supports that view.

22       CZARNECKI: I'm not sure I can provide a--

23       COHON: Paul, you have me confused now. This is Cohon,  
24 Board. Are you saying that the fast paths tend to be slower  
25 than you might have thought given their name fast path?

1           CRAIG: Well, fast path is a name which is used to  
2 distinguish matrix flow from flow through the cracks.

3           COHON: Right.

4           CRAIG: If it turns out that the matrix flow is of  
5 relatively small importance, for simplicity let's forget  
6 about it completely, everything is going through the big  
7 cracks, that's what we just heard from John, if everything is  
8 flowing through the big cracks, that's the dominant  
9 mechanism.

10          COHON: And if it's slow, then that's good news.

11          CRAIG: And if that dominant mechanism is slow, that's  
12 really good news, particularly if there are big hold-up  
13 times.

14          CZARNECKI: Can I make a comment? This comes back to a  
15 fundamental question that we've had, and that's regarding the  
16 gradient and the associated permeability at Yucca Mountain.  
17 There's two ways you can interpret that gradient. One could  
18 be that we have big flows going through large permeability  
19 zones, or we have very little flow coming through, and that  
20 supports this very small gradient. So it's open ended, and  
21 we still I think need to resolve that.

22          PARIZEK: Other Board questions? Staff? Leon Reiter?

23          REITER: Leon Reiter, Staff.

24                   John, Frank in talking about the regional model,  
25 emphasized a critical role of the carbonate aquifer. How

1 important--I was looking at your chart--how important is the  
2 carbonate aquifer in your model? Particularly I was thinking  
3 that we think the water coming through to Amargosa Valley  
4 goes through the tuff into the alluvium.

5           And just one other question. Yesterday, Russ Dyer  
6 when he was presenting work on TSPA, talked about using  
7 multiple lines of evidence to do reality checks on models.  
8 Are you doing any of these?

9           CZARNECKI: I'm going to use a viewgraph to help with  
10 the comment on the carbonate.

11           I think it's useful to review the distribution of  
12 the permeability within the carbonate. Since there's four  
13 darcies and it's at the base of the model, we get large flow  
14 occurring in this unit. It's also backed up in the vector  
15 diagram which just cuts through the middle of the model  
16 horizontally. But because this is such a high permeability  
17 within the model, it does have an impact.

18           The question related to reality checks, I have co-  
19 workers that are constantly reminding me of the geology in  
20 the area, and that vertical barriers that represent the large  
21 hydraulic gradient have not been found. And that kind of a  
22 reality check I think is useful because it forces one to look  
23 at other models. Another model that I'm looking at for that  
24 is to consider changes in permeability as a result of thermal  
25 alteration to the north, and instead of assuming a uniform

1 permeability within a given unit, we'll break it up into sub-  
2 parts. And that will allow us to do other types of models  
3 that the current assumptions with the individual units will  
4 not permit.

5           Another reality check is to compare what's coming  
6 out from Zell Peterman's work to look at other reinforcement  
7 from completely independent data sets. And this is one that  
8 we have begun to study. The hydrochemistry is supporting the  
9 types of results that we're seeing with respect to flow in  
10 and around Yucca Mountain, very valuable tool.

11         PARIZEK: Dan Bullen, Board?

12         BULLEN: Bullen, Board.

13           Just to maybe reiterate what Paul is saying and ask  
14 the question in another way, if water usage in the Amargosa  
15 Valley increases and the gradient increases, then the fast  
16 flow pathways become fast in Paul's definition?

17         CZARNECKI: That would be a consistent interpretation.  
18 There was a study done at our request to compile hydraulic  
19 head data for the Amargosa Desert. The report is one that  
20 was written by Kati Kilroy, and it compares conditions in  
21 1950 with those in 1987. And when you look at the  
22 potentiometric surface, you see cones of depression near the  
23 pumping centers, but they tend not to spread out too far,  
24 which is I guess encouraging. There's considerably more  
25 pumping in '87 than there was in '50, I believe, and a lot

1 more wells. So perhaps this phenomenon will be more  
2 localized than you or Paul may be concerned with.

3 BULLEN: Thank you.

4 PARIZEK: I think we ought to go on with our next  
5 presenter and thank John. This will be Bruce Robinson with  
6 current status of the saturated zone flow and transport  
7 model.

8 ROBINSON: There's been a lot of questions, comments and  
9 discussion on what some of these data collection and modeling  
10 efforts have to do with transport of radionuclides, and  
11 that's what I'd like to focus on in my presentation in  
12 describing the current status of the saturated zone flow and  
13 transport model. This is a collaborative effort in which  
14 John Czarnecki and colleagues at the USGS have been working  
15 with us at Los Alamos. And in addition, some of the modeling  
16 that I'll present today was the result of numerical model  
17 runs that were developed at Sandia National Laboratories.

18 This is an outline for what I'm going to be talking  
19 about today. I'd like to briefly describe the flow and  
20 transport models that are being used. It's fortunate in that  
21 I won't have to spend too much time on that given that the  
22 modeling that we're doing is very consistent between the USGS  
23 and Los Alamos, using the same code, the same model geologic  
24 framework and numerical grids to do the calculations.

25 And I'd like to present some radionuclide transport

1 studies of two radionuclides of interest, technetium and  
2 neptunium. I'd like to show how the saturated zone system  
3 behaves under one set of parameters for transport, and then  
4 focus the majority of my talk on some sensitivity analyses  
5 that look at some of the uncertainties associated with making  
6 a prediction of transport in the saturated zone. They're  
7 listed here. I'll get to them during the talk, so I won't  
8 discuss them any further right now, and then I'll summarize  
9 with some future work that we intend to do with this  
10 modeling.

11           This is a figure in your packet. I put it up only  
12 to keep you in place if you're following along in the papers,  
13 because you've seen this layout before, in fact in John's  
14 previous talk. This is the domain for the site scale model,  
15 the box that's shown here. There are a variety of models  
16 that have been used to predict flow and transport in the  
17 saturated zone. The largest scale model that's been used to  
18 predict radionuclide transport on the project is the site  
19 scale model.

20           It's a good model for determining general flow  
21 directions and transport directions. It has some limitations  
22 in its current setup that I'll discuss and talk about in the  
23 future work, but basically the resolution of the model is  
24 insufficient at the present time to capture the transport  
25 processes near Yucca Mountain, and that will be corrected in

1 an updated version of the model that goes to a much finer  
2 grid resolution. But in the meantime, what we've done is to  
3 try to develop transport calculations based on two models,  
4 and it's kind of summarized in this schematic.

5           The box is the site scale model domain and  
6 schematic over here. Embedded within that model for the  
7 purposes of this calculation is a sub-site scale model domain  
8 in which much greater resolution in the model was possible  
9 because of its smaller model extent, both aerially and  
10 planned view and also in depth. So I'll present transport  
11 calculations and results at both scales, but many of the  
12 simulations that I'll show are actually on the sub-site scale  
13 model domain in which we really have a finer discretized  
14 model that allows us to study things near Yucca Mountain in  
15 greater detail.

16           So the process here is to take results from a sub-  
17 site scale model, feed it into a site-scale model and come up  
18 with transport predictions, which I don't expect you to be  
19 able to see, but I'm going to discuss this slide in a future  
20 slide, discuss those results.

21           This is a permeability distribution in the sub-site  
22 scale model that I just described. It shows permeability  
23 values that coincide with the major hydrogeologic units that  
24 are present in the saturated zone. This is a model that was  
25 developed by Bill Arnold and collaborators at Sandia National

1 Laboratory. They developed the flow part of the model. I'll  
2 be running transport calculations and presenting the results  
3 of those in this talk.

4           You can also see that as John Czarnecki showed you  
5 in the site scale model, several features typically if one  
6 models the large hydraulic gradient as low permeability  
7 zones, then those need to be placed in the model, and this  
8 figure just shows where those are present in this model  
9 domain.

10           I just want to point out one other thing. This  
11 line that you see here is not an outline of the repository.  
12 I just wanted to point that out. It actually rests somewhat  
13 in here. It's an unfortunate plotting glitch and I don't  
14 want you to get the impression that that is the outline of  
15 the repository in this picture.

16           In order to make predictions of transport through  
17 the saturated zone, you have to have a source term, and the  
18 source term that I'm using for these are calculations of the  
19 mass flow rate of radionuclides through the unsaturated zone,  
20 which combines into the results of unsaturated zone flow and  
21 transport modeling, which is not the topic of this talk or  
22 this meeting. But in bringing you through these calculations  
23 and describing them, I'll focus on them for just a moment.

24           What you see on the left are the mass flux, the  
25 moles per year of radionuclide predicted from the unsaturated

1 zone models for technetium and neptunium, the two  
2 radionuclides that I'm focusing on today.

3           So this is what is reaching the water table  
4 according to the present models of flow and transport in the  
5 unsaturated zone. What's built into these calculations are a  
6 1,000 year canister lifetime, so that I'm trying to outline  
7 for you the assumptions that go into these curves, a 1,000  
8 year minimum lifetime for canisters, followed by releases  
9 from the near-field over in the case of technetium, 3,000  
10 years, and 30,000 years for neptunium, and these are the  
11 break-through curves at the water table that serve as the  
12 source for the saturated zone calculations. So we're going  
13 from unsaturated zone, we're hitting the water table, fed  
14 into saturated zone transport models, and the results are  
15 shown on the right-hand side.

16           The different curves are for different infiltration  
17 rates. They kind of give you a feel for the amount of  
18 uncertainty based on one of the key parameters in the  
19 unsaturated zone where infiltrations and how those play out  
20 in terms of mass flow of radionuclides hitting the water  
21 table.

22           Now, on the right-hand side are the calculations of  
23 the concentration out at five kilometers using the sub-site  
24 scale model that I described. And this is for technetium and  
25 neptunium. Now, there are several cases involved here.

1 Basically, the three curves here are put into the saturated  
2 zone model and the break-through in terms of concentrations  
3 at the five kilometer point that was studied here are shown  
4 in these curves.

5           One of the key parameters at least for  
6 radionuclides such as neptunium is the sorption coefficient.  
7 Even values of sorption coefficient that chemists would  
8 describe as small, two cc's per gram, result in significant  
9 delay in radionuclide travel time. So that's one of the  
10 sensitivity analyses that I'll show in a minute.

11           Now, the result from the sub-site scale model are  
12 in a sense digitized and placed into the saturated zone site  
13 scale model to perform calculations out to 20 kilometers,  
14 more in line with the current thinking on the compliance  
15 point that you would be computing and predicting.

16           This red curve was a five kilometer compliance  
17 point, similar to one of the curves that I showed in the  
18 previous slide. When you go to the longer travel times, you  
19 get additional dispersion and mixing according to these  
20 models that result in essentially lower concentrations as a  
21 function of distance.

22           Now, this is one of the key uncertainties that I  
23 think we need to look at in greater detail, and that is the  
24 nature of dispersion in this system, because models will  
25 typically always predict mixing and dilution caused by the

1 dispersion of a contaminant as it travels along the flow  
2 pathway. We need to look at that model in detail and make  
3 sure that we think it's a realistic assessment.

4           Now, there are different curves on this plot.  
5 Basically, there is a sensitivity also to what you assume for  
6 the porosity of the medium. This is getting to some of the  
7 questions that were discussed earlier. I'm going to talk  
8 about the porosity in some of the sensitivity analyses.

9           Let me give you a flavor for all of the sensitivity  
10 analyses that are described here. I'm not going to have time  
11 to talk about them very much, except to touch on them.

12           One can either do a very detailed job in placing  
13 radionuclides at the water table as a function of position  
14 and try to make those predictions based on an unsaturated  
15 zone model, or you can just lump it all together and put it  
16 into a model uniformly over the entire domain.

17           What I'm showing here is a comparison of  
18 radionuclide that hits the water table at different locations  
19 in the sub-site scale model. Depending on what unit is  
20 encountered by percolating radionuclide, Prow Pass, Bullfrog  
21 and Tram, one gets somewhat different plume migration  
22 directions. And so the conclusion here is that the plume  
23 trajectory and the concentration hitting the water table  
24 needs to be considered at least in terms of which rock unit  
25 is encountered when those percolating radionuclides hit the

1 water table.

2           Probably this effect is most important if one is  
3 focusing on something five kilometers downstream, but as we  
4 get to greater distances away from the repository, the whole  
5 thing looks a lot more like a point source at the repository  
6 and at Yucca Mountain.

7           Next is the effective porosity. What I show on the  
8 left here are sort of generic transport calculations, the  
9 response of the saturated zone system to a constant input of  
10 radionuclide. That's on the left. And what I'm showing is  
11 the break-through time basically is controlled by what one  
12 assumes for the porosity of the medium.

13           If you assume that radionuclides travel only within  
14 fractures, one would select a porosity something like .0001  
15 in the extreme, or perhaps .01. What I'd like to point out  
16 is that the travel times that are backed out from that sort  
17 of calculation are on the order of one to ten years, out to  
18 five kilometers. Is this consistent with the data that we  
19 have, the hydrochemical data that we have for the site? I  
20 believe no. I believe that porosities more like matrix  
21 porosities are more appropriate based on the hydrochemical  
22 evidence that we have so far. However, I think we need to do  
23 more in the area of study and actually getting into our  
24 numerical models the influence of or the constraint, the  
25 additional constraint of the hydrochemical data. What that

1 will allow us to do is to constrain and narrow the bounds of  
2 possible porosity values that we put in these models.

3           Now, the porosity, the effective porosity that one  
4 assumes has the greatest influence on the arrival times. It  
5 perhaps doesn't have as great an effect on the amount of  
6 dilution that one would predict from a model, because the  
7 porosity will affect the travel time more so than the  
8 dilution of radionuclides entering the saturated zone and  
9 becoming diluted with water that's travelling past it in the  
10 saturated zone.

11       COHON: What is the base case value? Is it .3?

12       ROBINSON: In this calculation, it was on the order of  
13 .3.

14       COHON: Was it .3?

15       ROBINSON: I believe it was .3. I'd have to look it up.  
16 But it's very close to that. Clearly, greater than .1. I  
17 think it's .3 is about right.

18       SAG<sub>γ</sub>ES: I don't understand the colors in the technetium  
19 predictions curve on the right.

20       ROBINSON: Okay.

21       SAG<sub>γ</sub>ES: Which one is the base case in that curve there?

22       ROBINSON: Red.

23       SAG<sub>γ</sub>ES: And then as you go to lower porosities, it  
24 moves faster?

25       ROBINSON: Absolutely. Think of it as a displacement

1 process in which the travel time is governed by, in essence,  
2 the flow rate--or excuse me--the volume of fluid that needs  
3 to be displaced, divided by the flow rate of that fluid.  
4 That will give you travel time. So the lower the volume of  
5 fluid, i.e. the lower the porosity, the more rapid the travel  
6 time.

7 SAGYES: Right. Because you don't have to fill the  
8 pores and the cracks.

9 ROBINSON: That's right.

10 We saw that there was uncertainty in the perceived  
11 or computed fluid flow rate through the saturated zone. This  
12 would be under base case or present day conditions, but also  
13 factoring in the effect of a changing climate and the  
14 uncertainty that that gives us in terms of the flow rate.

15 This is just an example of what happens in the  
16 model calculations if one assumes a fives times greater flow  
17 rate. Greater flow rates in the saturated zone result in  
18 lower concentrations on this sort of a calculation, which  
19 again is a constant source at time zero. And that gives rise  
20 in terms of a prediction to a lower concentration.

21 So there's a trade-off, if you will, in terms of  
22 how flow rate or flux through the saturated zone affects  
23 these model results. If everything is going to get to an  
24 accessible environment point within a compliance period, then  
25 the higher the flow rate, the greater the dilution, and

1 that's a good thing.

2           If, however, one's predictions say that the travel  
3 times are greater than the compliance period, then anything  
4 that speeds that up and brings it to the accessible  
5 environment sooner would be, in essence, bad from the  
6 standpoint of performance. So the flow velocities impact  
7 both the travel time and the amount of dilution that we  
8 predict in these models.

9           Next topic is the influence of repository heat. We  
10 ran calculations in which we imparted, gave a temperature  
11 wave that hits the saturated zone due to the repository heat  
12 effects, and this is just an example of temperature  
13 distribution within the saturated zone, both in plan view and  
14 side view. The types of temperature rises at the water table  
15 that have been discussed are on the order of 50 to 60 degrees  
16 C. These, according to this model, are transported somewhat  
17 through the saturated zone. So you do get, in essence, a  
18 plume of fluid that's somewhat higher temperature than the  
19 ambient for a period of time, and it abates as the heat from  
20 the repository abates.

21           The question here is what influence might that have  
22 on saturated zone flow and transport? The predictions on the  
23 right-hand side, if you focus on just the two colored curves,  
24 those are concentrations of technetium under similar  
25 assumptions for all the transport properties, but one in the

1 influence of the heat and one without. And it turns out it  
2 has a very minor effect on the predicted transport through  
3 the saturated zone.

4           Now, the assumption, the key assumption made here  
5 is that there would be no durable changes in the hydrologic  
6 properties due to this heat. We know that there will be some  
7 mineral redistribution associated with the flow of water and  
8 the migration of a thermal plume, and this might influence in  
9 fact the calculation of transport properties, because the  
10 hydrologic properties may change. Those are not included in  
11 these simulations. Our initial looks at that suggest that  
12 that would also probably be a minor effect, but I think I'd  
13 like to make that a soft conclusion at this point, too,  
14 because we haven't looked at it as much as we perhaps should  
15 have.

16           Sorption in the saturated zone is another aspect of  
17 transport of radionuclides that is clearly important. What  
18 we do to make these sorts of predictions is to identify in  
19 the case of the important radionuclides the minerals that are  
20 implicated in the sorption. And in the case of neptunium,  
21 sorption to zeolites appears to be the primary mineral,  
22 clinoptilolites for sorbing and retarding neptunium.

23           We take the mineral data bases that have been put  
24 together, embed them or superimpose them on top of our  
25 numerical grids, and then perform the calculations of

1 transport, assuming a retardation factor that is, for this  
2 simulation, 2 cc's per gram in the zeolitic zones, and zero  
3 elsewhere.

4           That sort of transport Kd parameter has a  
5 significant retarding factor for the case of neptunium, in  
6 this simulation, on the order of 10 to 20 delay in travel  
7 times of neptunium relative to a conservative radionuclide.

8           Colloids is the next topic. This slide is a  
9 sensitivity parameter, or a sensitivity analysis on what we  
10 think is probably the key parameter that will decide for us  
11 the importance of colloid facilitated transport of  
12 radionuclides such a plutonium.

13           This is an example of a simulation of plutonium  
14 concentration at a compliance point versus time for different  
15 values of a partition coefficient,  $K_c$ , which I'll describe  
16 now.  $K_c$  basically is the relative partitioning of plutonium  
17 onto colloids versus that in the aqueous phase. So if there  
18 is no partitioning onto colloids and/or those colloids are  
19 not mobile, one predicts very long travel times for plutonium  
20 through the saturated zone, in the saturated zone alone,  
21 would delay plutonium, because of the high Kd that's assumed.

22           However, what happens if you assume that most of  
23 the plutonium resides on colloids, and furthermore assume  
24 that those colloids are mobile, transport times to the  
25 accessible environment come within 10 to 100,000 years out to

1 the 20 kilometer compliance point. So the work that's going  
2 on now is attempting to come up with parameter values for  
3 this parameter.

4 I think that currently, the numbers that are being  
5 estimated for this partition coefficient are in fact closer  
6 to zero than certainly they are to 99. They tend to range  
7 from about zero to one in most estimates of this partition  
8 coefficient. That would place plutonium into the longer  
9 travel time range that we assume in the absence of colloid  
10 transport.

11 Final sensitivity analysis is the effect of  
12 dispersivity. We saw some estimates from the C-Wells  
13 experiments. Those estimates provide kind of a starting  
14 point for estimating the dispersion coefficient or the  
15 dispersivity in the field scale models. One has to scale  
16 those for the distance of travel. You're talking about 30  
17 meters or so of travel in the C-Wells experiment versus a 5  
18 or 20 kilometer travel distance in these simulations.

19 So these are predictions of break-through and  
20 concentration at a compliance point for different values of  
21 the dispersion coefficient. Now, these are dispersivities  
22 longitudinal and transverse. And the point here that I'm  
23 wanting to make is that it's actually the transverse  
24 dispersion, something that we don't know a whole lot about,  
25 that really is going to be a key consideration in computing

1 what the--how much dilution can be attributed to dispersion  
2 effects within the saturated zone.

3           This is just a rundown of some of the things that  
4 we're going to do in the future. Combining the sub-site and  
5 site scale models I think is an important thing that we're  
6 working on at the moment to try to eliminate the step of  
7 having to piece different models together. It's a  
8 computationally intensive problem that we're working on at  
9 the present time.

10           I think constraining a model with hydrochemical  
11 data of the sort that was discussed this morning is an  
12 important next step. One can run chemical transport  
13 calculations to provide further constraints on flow models,  
14 and I think that's one of the things that we're focusing on  
15 at the moment.

16           Dispersion is extremely important. We need to  
17 start incorporating into our models more heterogeneous  
18 systems to look at dispersion in more detail. Dispersion in  
19 the saturated zone is shown to be a key element in the  
20 predicted dilution of radionuclides, and so it needs to be  
21 looked at in greater detail.

22           Some of the alternate conceptual models for flow  
23 related to the large hydraulic gradient and other things; I  
24 believe that those need to be looked at in terms of  
25 implications for transport. Even if you argue that they're

1 up stream from the repository, I think that we could surprise  
2 ourselves if we assume that just because it's up stream of  
3 the repository that it's really not going to have any  
4 influence on migration away from the repository.

5           And, finally, looking at elements of colloid-  
6 facilitated transport is a key component in the transport  
7 studies that we're working on right now.

8           That's my conclusions. I'd like to open it up for  
9 questions and just provide the conclusions as part of your  
10 packets, and address any questions you might have.

11          PARIZEK: Debra Knopman, Board?

12          KNOPMAN: Can I just ask a question, Dick? What's our  
13 schedule going to be with regard to lunch?

14          PARIZEK: Well, we're set up for more or less a quarter  
15 past 12:00 is what's on the schedule. But let's take  
16 questions while we have a speaker available.

17          KNOPMAN: Bruce, I found the sensitivity studies very  
18 interesting. However, they're of course contingent on  
19 whether you parameterize the model correctly and whether the  
20 conceptual model has any validity in and of itself.

21                 In terms of these transport matters, what can you  
22 tell us about the kind of testing you've done of alternative  
23 conceptual models, and what effect that would have on your  
24 particular sensitivities and some of these maybe key results?

25          ROBINSON: I think one of the key aspects that's been

1 brought out in the discussions today is this idea of the  
2 effective porosity that's available for transport of a  
3 contaminant, a radionuclide, as opposed to flow of water.  
4 Now, underlying the parameter sensitivity studies that we've  
5 done here, we've looked at conceptual models that are more  
6 idealized, but allow us to get at the kind of time scales  
7 that are required for, say, a radionuclide travelling through  
8 a fracture to diffuse into the rock matrix and, hence, be  
9 delayed relative to one that just squirted through the  
10 fractures, if you will.

11           That sort of analysis implies that the fracture  
12 porosity is probably quite a bit lower than the effective  
13 porosity that one would have in the presence of, say, matrix  
14 diffusion. That's why the results of the C-Wells experiments  
15 I think where matrix diffusion has been identified as a  
16 process that is occurring in those tests is very important,  
17 because we can do all the calculations we want and say that,  
18 well, it looks to me like it should have enough time to  
19 diffuse into the matrix and, hence, we should have longer  
20 travel times. Credible field evidence of that has been hard  
21 to come by, and that's a way in which that sort of data is  
22 being used in our thinking and in our development of these  
23 models.

24           PARIZEK: Priscilla Nelson?

25           NELSON: Nelson, Board.

1           Thinking about the importance of dispersivity, I  
2 could see how it's important that, for example, a five mile  
3 compliance point, particularly when you look at a point  
4 source effectively. But if you look at a distribution of  
5 point sources where the radionuclides might be delivered  
6 according to some distribution of fast paths or whatever from  
7 the unsaturated zone to the saturated zone, how important is  
8 it that efforts be taken to evaluate the dispersivity?

9           ROBINSON: I think the dispersivity is an extremely  
10 important component to a first approximation--let me back up  
11 before I say to a first approximation. The unsaturated zone  
12 transport models when combined with models for how the  
13 canisters fail and that sort of thing, usually give you a  
14 very long time period over which radionuclides are going to  
15 be hitting the saturated zone. Okay?

16           Now, the only thing that will dilute them beyond  
17 that in the saturated zone is the rate of flow of fluid. If  
18 you conceptualize the saturated zone as just a pipe that's  
19 transmitting water and radionuclides, it's the relative flow  
20 rates of the downward percolating radionuclides with the flow  
21 rate in the saturated zone. There's that factor.

22           There's also the spreading of that plume as it  
23 travels down gradient. The conceptual models range from,  
24 well, I think that a radionuclide plume really stays pretty  
25 compact and it just kind of bends with the flow, it doesn't

1 really spread out that much, versus one in which dispersion  
2 or dispersivity really does spread it out and results in  
3 lower concentrations. I think pinning that down on a  
4 scientific basis will really constrain our calculations of  
5 the performance in the saturated zone. It's very important.

6 NELSON: But if there's many, many point sources--

7 ROBINSON: You mean at the repository?

8 NELSON: Just all over the projection of the footprint  
9 onto the UZ/SZ interface. And you don't know where these  
10 are, but there may be many, you know, over time arriving and  
11 entering the saturated zone, so that I guess I'm wondering,  
12 it seems like if you're talking about many point sources all  
13 starting at different times perhaps somewhat, that the  
14 importance of dispersivity as a parameter to try to evaluate  
15 might be somewhat reduced.

16 ROBINSON: I don't think so, because the way I think  
17 about it is you have a repository, and if you assumed a first  
18 approximation that the footprint of the repository that you  
19 project down onto the water table, maybe that's where the  
20 radionuclides are going to be basically travelling, downward,  
21 vertical flow in the unsaturated zone. That's about three  
22 kilometers or four kilometers by one. You're talking about  
23 travel distances out to 20 kilometers. That repository  
24 footprint begins to look a lot like a single point source  
25 when you go way out to 20 kilometers.

1 COHON: And that's my question. Cohon, Board.

2 You're going from a sub-site model to a site model  
3 to a regional model. And this comment about the repository  
4 appearing to be just a single point source from 20 kilometers  
5 away, how much of that is model, the fact that you're going  
6 from one model to another, and the last model has very gross  
7 spatial scale, relatively speaking? And what effects does  
8 that introduce into the conclusions?

9 ROBINSON: I don't think it's model dependent. I'm  
10 making sort of an argument based on, you know, just the  
11 geometry of the repository layout and how that might be  
12 imprinted on the water table as a source term for  
13 radionuclides versus the travel distance. I don't think  
14 that's dependent on the models. To be sure, we want to have  
15 ideally a single model that would capture the resolution  
16 needed to really get the detail near Yucca Mountain embedded  
17 within a larger scale model that maybe doesn't have as much  
18 detail out at the peripheries of that model, right out to the  
19 site scale model boundary. That's what we're working on now.  
20 There aren't any plans to go and actually embed that within  
21 the regional scale model. Those two modeling activities  
22 right now are distinct and we go back and forth from one to  
23 the other for consistency. Basically, the regional scale  
24 studies in my mind tell us, in the simplest sense, tell us  
25 what we think the flux might be through the site scale model

1 domain.

2 COHON: Okay.

3 ROBINSON: And those are in fact pretty consistent.

4 COHON: Just one last very quick question. You said  
5 that the site scale model will be converted to a spatial  
6 scale that you're working at now at the sub-site model. When  
7 will that be done? When will that be accomplished?

8 ROBINSON: I'm going to tell you the current progress,  
9 and then when it will be accomplished will have to be a  
10 little bit of a prediction.

11 COHON: That's fine. Just what's your prediction? You  
12 don't have to give me the details of what you're doing; just  
13 what's your prediction? A month?

14 ROBINSON: Okay, probably--no, no, it will be more like  
15 four to six months.

16 COHON: Thank you.

17 PARIZEK: Parizek, Board.

18 The importance of the colloidal transport  
19 mechanisms, I know in the C-Well tests or tests like that  
20 where you're injecting and pumping, youi really induce  
21 artificial gradients in the system. The natural gradients  
22 are very gentle in this sort of area. And so the question is  
23 how do you get at the colloid migration that really occurs  
24 under natural conditions, natural gradients? It may be a  
25 question that's hard to answer, but I can leave it hang for

1 later discussion this afternoon.

2           ROBINSON: I think there's tremendous uncertainty, and  
3 if I would say so, confusion out there right now about how  
4 important colloid facilitated transport is. I'm not saying  
5 everybody else but me is confused. I'm trying to put it  
6 together myself as well. I think experiments like the C-  
7 Wells kind of give you a ground truth, but they need to be  
8 augmented by much more detailed laboratory studies that look  
9 at the properties of real colloids as opposed to--let me say  
10 natural colloids as opposed to microspheres, to look at the  
11 transportability, if you will, of the colloids.

12                   And there's another factor to consider when  
13 considering migration of radionuclide on a colloid, and that  
14 is how strongly attached is a radionuclide to the colloids.  
15 So it's this relative partitioning between the aqueous phase  
16 and the colloids that's important as well. So it's the  
17 transportability of the colloids, and also the chemical  
18 interactions of the radionuclides with the colloids that's  
19 going to be the final arbiter in how important colloids are.

20           PARIZEK: Alberto Sagnes?

21           SAG<sub>γ</sub>ES: Yes, Sagnes, Board.

22                   When you talk about the heterogeneous model  
23 formulation, do I understand correctly you're talking about  
24 models in which you have like fractures, and then porous  
25 materials on the side of the fractures and, therefore, you're

1 considering transport through the fractures and then the  
2 demands needed to fill up the surrounding rock? Is that what  
3 you mean by the heterogeneous models?

4       ROBINSON: Not exactly. Basically, the heterogeneous  
5 simulations that are being performed are attempting to take  
6 into account fracture densities and that kind of thing, but  
7 to do calculations using a continuum representation. In  
8 other words, a block of rock still has a given permeability;  
9 it's just that what we want to model is variations in  
10 permeability that you might see due to these fractures, but  
11 on a smaller scale than has been done so far in these models.

12       SAGYES: But the presence of like the cracks surrounded  
13 by a sponge type of model which you see in some other  
14 disciplines, that's not in the plans right now?

15       ROBINSON: Well, that can be an element of the transport  
16 simulations as opposed to the flow simulations, and in fact  
17 we tend to use continuum models more for the flow  
18 calculations, and when we really go to transport, we need to  
19 include some of these concepts like the matrix diffusion  
20 concepts.

21       SAGYES: Okay, thank you.

22       PARIZEK: Questions from Staff? If not, we thank you  
23 very much. Our next speaker will be Linda Lehman, State of  
24 Nevada studies of the saturated zone, and she's president of  
25 Linda Lehman and Associates and comes to us from Minnesota.

1           LEHMAN: Good afternoon, everyone. Thank you for the  
2 opportunity to present the State of Nevada's research in the  
3 saturated zone.

4           Most of this work has been performed over the past  
5 eight to ten years of working for the state. What I'd like  
6 to cover today is some of the work that we did on the water  
7 table frequency analysis, the response of the water table to  
8 rainfall or whatever natural phenomenon occur that change the  
9 water label.

10           We looked at the water table wells, and we also  
11 looked at the response of Devil's Hole. We also did an  
12 analysis of the response of the water table to the  
13 earthquakes which occurred, the Landers Earthquake and the  
14 Little Skull Mountain Earthquake in 1992, and the results of  
15 these studies helped shape our conceptual models of the  
16 saturated zone.

17           And with respect to the conceptual models, the flow  
18 models, I'd like to present our conceptual flow model and the  
19 numerical model that we've done, and then also what we feel  
20 is needed in addition to what we've done in the past.

21           The water table analysis was done in the late  
22 1980s, about seven or eight water table wholes, which at that  
23 point in time had data. Our analysis basically was to first  
24 remove any linear trends that we saw in the data, for  
25 example, this declining trend. After that trend was removed,

1 then we wanted to do a spectral analysis, essentially, and we  
2 looked into Forier transform analysis and found that we would  
3 have a problem applying any of those because the data were  
4 not evenly spaced in time.

5           So we simulated the Forier analysis by fitting a  
6 cosigned function, and we used a code which we developed  
7 called FIT.M. So basically, after removing the linear  
8 trends, then we fit a cosigned function to the data to see if  
9 we could get any cyclic movement.

10           This is WT-1 analysis, and as you can see, we did  
11 come up with some cycles. These cycles are very small.  
12 However, they do give you some information.

13           On most holes, we basically could group two  
14 consistent groups of responses. the first was WT-7 and WT-  
15 10, and I'm going to put these up over here while I'm talking  
16 about them so you can see it.

17           This has about an average of about close to a  
18 thousand day period, maybe 970 days, something like this, and  
19 the phase shifts were quite similar.

20           The second group that caught our eye was WT-1, 11  
21 and 16, and they all sort of hovered around an 870 day  
22 period, with a phase shift of about 250 days.

23           When you look at these on this viewgraph, what  
24 you'll find is that they are spatially distributed as well.  
25 For example, the longer period of response fell to the west

1 side of Yucca Mountain along the Solitario Canyon. The  
2 shorter period, the 870 day period, was on the right-hand  
3 side, or the east side of Yucca Mountain, and also was in a  
4 linear trend, which is parallel to the extensional faults  
5 zones that we see in Yucca Mountain. The very long periods,  
6 as you will see, coincide with like the crest of Yucca  
7 Mountain and other elevations.

8           Seen another way, looking across the mountain from  
9 west to east, we have the longer period response on this  
10 side, shorter period here, and then a very long response  
11 under Yucca Crest. And this was our first indication that  
12 the flow field on the west side of the mountain was different  
13 than the flow field on the east, and as Zell Peterman has  
14 told you, there are some major ion chemistry differences as  
15 well, and Nancy Matuska at the Desert Research Institute at  
16 that time had done some major ion chemistry and supported  
17 this idea of separate flow fields.

18           I think today we're still doing most of our  
19 modeling as if it were one flow field, but I think we now  
20 have evidence that it is probably separate systems, at least  
21 loosely connected.

22           We looked to see if there was something that would  
23 be causing these roughly two and a half to three year cycles,  
24 and John Fordham at DRI in Reno provided us some information  
25 about the annual precipitation, and what you'll see is that

1 the deviation from mean of the annual precipitation follows a  
2 roughly two and a half year pattern as well. So we think  
3 that possibly this is some signal in response to rainfall.

4           So basically, our conclusions from the frequency  
5 analysis were that there is linearity in these responses, and  
6 we believe that it was structurally controlled, and that the  
7 flow field and frequencies were different on each side of the  
8 block, and this two and a half year rainfall distribution.

9           We also applied this analysis at Devil's Hole, and  
10 this is just a map to orient you to where Devil's Hole is.  
11 It's not too far from here. Devil's Hole is a spring, for  
12 people who don't know about it, emanating from the  
13 carbonates. And before the earthquakes, we had done an  
14 analysis to look at the water use there and had found that  
15 there was a significant declining trend which really started-  
16 -our analysis started way before '89, but this is a plot from  
17 '89 to '92, before the earthquakes, and it was very much  
18 declining.

19           After the earthquakes now, we did this same  
20 analysis again to look at the trend, and what we found was  
21 that the trend was quite different. It had now flattened  
22 out, and this was not only a function of the earthquakes, but  
23 we believe it reflected the increased rainfall that came in  
24 the winter of '92 and early '93. So this later part here of  
25 the analysis actually flattened this curve out quite

1 considerably.

2           With the earthquake data, that bottom line there  
3 was without the earthquake data, this is the response at  
4 Devil's Hole, this decline from the Landers and Little Skull  
5 Mountain Earthquakes. As you can see, it was really a steep  
6 decline, and then it recovered again to higher levels.

7           So whether we use the earthquake results or not in  
8 here, it really made no difference. It was pretty much a  
9 level line.

10           So after removing that small linear trend, we then  
11 looked at the cosine function using FIT.M once again, and we  
12 came up with a period of approximately 350 days, so we  
13 assumed that that was pretty close to an annual cycle that  
14 was reflected in Devil's Hole.

15           In addition to the annual cycle, we could also see  
16 a larger cycle, once we subtracted this annual cycle out, of  
17 about a 3.8 year period reflected in there as well, and we  
18 don't really have an explanation for that cycle.

19           We also looked at the response of wells in the  
20 region, not just Devil's Hole, and some interesting  
21 conclusions came out of this work. What we found was there  
22 were basically four types of responses to these earthquakes.  
23 The first was a sharp increase and then an immediate  
24 recovery. The second type was a sharp increase with no  
25 recovery. It was a sustained deviation. And the same in the

1 reverse, decline and recovery, or decline and sustained  
2 decline.

3           We first noted that it was interesting that Devil's  
4 Hole had a sharp decline and a sustained one for a short  
5 period of time, and then right next to it, all the adjacent  
6 wells showed an increase in water level. So we started  
7 wondering, well, why could this happen, and we remembered  
8 that there is a fault zone there and we believe that these  
9 structures actually are controlling the response.

10           So we looked around the region and plotted these  
11 wells in regard to the different fault zones, and what we  
12 found was that in the extensional zones, which are the dotted  
13 lines, that consistently we saw a water level drop, but in  
14 the transform faulting, the shear zones, we consistently  
15 found rises, and these are these zones this way.

16           So basically our observations were, as I just told  
17 you, the shear zones increased and extensional zones  
18 decreased. Again, this kind of reinforced our structurally  
19 controlled idea of the flow system, and at this point, we  
20 decided we would attempt our own modeling exercises to see  
21 what we could come up with in terms of flow paths at Yucca  
22 Mountain. And in doing so, we started looking at the  
23 available data.

24           Well, basically there are a couple of types of data  
25 that you can use that were available at the time upon which

1 to calibrate your models, and the first is potentiometric  
2 data and the second is temperature data. Temperature can be  
3 a very good indicator of flow paths.

4           We looked at the potentiometric data, and this was  
5 a 1984 potentiometric surface by the U. S. Geological Survey.  
6 After this surface was done, they decided to go back and re-  
7 level a lot of the holes. There was some discrepancy whether  
8 or not these elevations were correct. And they also  
9 corrected the water table measurements for temperature and  
10 density, and when they did that, they published a new  
11 publication, 1995, and in this publication, you can see that  
12 the water table surface is quite different. I'm going to put  
13 these both up here for a moment so you can see that these  
14 embayments up near Drill Hole Wash and below the repository  
15 footprint had disappeared essentially from this new  
16 potentiometric surface.

17           This essentially, if you were going to use this as  
18 your guide for flow paths, you would assume that flow would  
19 be moving pretty much to the southeast from the northwest, or  
20 diagonal to these lines.

21           We wondered what happened to the embayments here,  
22 so we went back and looked at the actual data that they used  
23 in the report, and in the report, they had a paragraph, a  
24 caveat that says basically that a lot of these data here in  
25 this area, they didn't use it because they couldn't explain

1 it. They felt there was no physical explanation for the  
2 data. And we felt differently because we felt it was  
3 coincident with some of these shear zones, so we went ahead  
4 and took their actual data from the report and plotted it.  
5 And I want you to notice particularly this 730 meter contour  
6 line. And their data when potted, you can see that it is  
7 coincident with the traces of the Sundance Fault and the  
8 Drill Hole Wash Fault. Each place you have these embayments.

9           This embayment here when we plotted it, we thought  
10 well, maybe there could be another fault in here, and I  
11 believe Bill Justice told me when they did the C-Well test,  
12 they actually did discover that there was a fault here, but I  
13 predicted it on the basis of this embayment.

14           I've also lately been told that the Ghost Dance  
15 Fault trace does not extend beyond--I mean, the Sundance  
16 Fault trace does not extend beyond the Ghost Dance. But to  
17 me, that is not so important. I think what's important here  
18 is that we do have fault intersections that are controlling  
19 the direction of flow.

20           So if you were to take this map to calculate your  
21 flow paths, it would be quite different. You would see flow  
22 coming into these faults like this, moving into it rather  
23 than straight across. So it's quite a different flow path  
24 than had you just used this straight potentiometric surface.

25           So we're quite concerned that anyone doing the

1 modeling should use the correct potentiometric surface, and  
2 don't be too quick to throw out your data points. Look at  
3 them first.

4           As I said, temperature is another indicator and  
5 another data base that can be used to determine your flow  
6 paths. So the available temperature here was done by Sass in  
7 the late 1980s, and as you can see what's happening here, I  
8 hope, is that there is a very high heat loading here to the  
9 west on Solitario Canyon, and this is close to those volcanos  
10 that exist, 38.8 degrees centigrade, essentially, compared to  
11 the center point of the mountain itself, and here is the  
12 footprint, but you can see a cold water plume moving down the  
13 center of the mountain. And at some places, this is 30  
14 degrees C., so we have an eight, almost nine degree  
15 temperature drop within like a kilometer--two kilometers at  
16 best.

17           Then again a heat source here following Midway  
18 Valley extensional zone, and then over here in Forty Mile  
19 Wash, we have another cold water zone.

20           So given that temperature distribution, we then  
21 came up with some flow paths that would be likely based on  
22 that temperature, and saw that essentially the flow is coming  
23 down from the north, the cold water is up here on the north  
24 side of the hydraulic gradient, what little data we have, we  
25 know it's cold, moving down almost coincident with the Ghost

1 Dance Fault trace, and then moving out into the Midway Valley  
2 area. There may be some intrabasin flow coming through the  
3 lower part of this graphic here.

4           I do want to just put one thing back up here for a  
5 moment, and maybe you can see some similarities. I noticed  
6 these similarities right away. If you'll look at the stress  
7 field and assume this is a transform faulting situation, what  
8 you have is this zig-zagged pattern where you have shearing,  
9 shearing, extension, and then on this side, you have both  
10 plates moving at the same, together.

11           So I see this pattern here in this flow path. How  
12 real it is, I don't know. We have to construct some models  
13 and do a lot more work, but at the same time, it does give  
14 you a visual indication that it is moving along these fault  
15 zones and is structurally controlled to some extent.

16           I have to apologize for this slide. It may not be  
17 too clear. But this is our grid that we developed for the 2-  
18 D model. We used A-TOUGH, which was developed by Parvis  
19 Montazer. We can run it on our PC. We were using V-TOUGH  
20 and had to run it on the Cray at UNLV, so we really were  
21 appreciative that Parvis took the time to put this on a small  
22 computer.

23           Basically, we included the faults explicitly in our  
24 model. The scale here is somewhat smaller than the sub-site  
25 scale model that you just saw from Bruce. This is the trace

1 of the Ghost Dance Fault and the Midway Valley fault zone,  
2 and over here, the Solitario Canyon Fault.

3           Now, we do have different permeabilities assigned  
4 to these because as we said before, the different fault  
5 zones, you know, are not all transmissive. Some are quite  
6 tight. We did simulate the hydraulic barrier that John  
7 Czarnecki was just talking about with a very tight zone here.  
8 And then because it was tight in going into a regular tuff  
9 type of permeability, we had to have a transition zone so  
10 that our model would stabilize.

11           But basically, this zone is more transmissive.  
12 This zone is transmissive. And these northwest shears are  
13 less transmissive, as is the Solitario Canyon, and you can  
14 see the numbers that we have used for permeability in these  
15 various zones.

16           Some of our initial runs, and we didn't get to do  
17 very many runs before our funding was cut, but we felt that  
18 we actually did accomplish quite a bit with these few runs,  
19 here's the actual potentiometric surface. This is the 730  
20 meter contour line, and as you can see, we did manage to get  
21 those embayments shown on here, maybe not exact, but at least  
22 we got them in.

23           And then with our temperature match, here's the  
24 actual temperature and here's our simulated results. We did  
25 manage to get a cold water plume, this is the 31 degree

1 contour, and then the hotter water here, and hot water here  
2 again.

3           However, what we realized was that this was not  
4 really adequate, because with the significant temperatures,  
5 we felt this water was up-welling and probably from the  
6 carbonates, and work a little bit later on in time, the last  
7 year or two by John Bredehoeft for Inyo County, John took  
8 some of the data from P-1, the only carbonate well, looked at  
9 the temperature and calculated through the use of earth tides  
10 what would be the bulk permeabilities and the head  
11 relationships from the carbonates, and he calculated  
12 basically that there was a 20 meter head difference. The  
13 carbonate was higher by 20 meters than the tuff aquifer.

14           So we feel that there is a significant component  
15 that needs to be accounted for. And as you saw, so far, no  
16 one is using temperature as an indicator. We feel  
17 temperature is very critical, and we don't also agree with  
18 this no flow boundary condition on the bottom. We feel like  
19 we have to account for upward flux.

20           So the next step in my opinion would be to take  
21 this lower temperature boundary, and this is from Fridrich  
22 from the USGS, and it was recently used by John Bredehoeft in  
23 his water resources research article on this topic. This is  
24 looking from the south to the north. This says to the north,  
25 but it's from--to the south, but it's from the south. This

1 is Solitario Canyon, the high heat loading here, the 38  
2 degree temperature. This is the Midway Valley, extensional  
3 fault zone, and then here is Yucca Mountain with all of this  
4 cold water down through the middle of it.

5           So we feel that we need to incorporate this now  
6 into a three dimensional flow model which accounts not only  
7 for the correct potentiometric surface, but also this  
8 temperature difference, because it is significant across the  
9 site in a small horizontal distance.

10           So that's where we stand now, and if you have any  
11 questions, I'd be happy to answer them.

12           PARIZEK: Questions from the Board? Questions from  
13 Staff?

14           (No response.)

15           PARIZEK: Okay, we thank you for your presentation. We  
16 have a chance for one more, and this has to do with Nye  
17 County proposed saturation zone EWDP. Parvis Montazer will  
18 make the presentation, and we'll try to finish as promptly as  
19 we can to make it to lunch, and we'll have to postpone  
20 getting back here until 1:30, 1:35, depending upon how long  
21 the presentation takes.

22           Thank you.

23           MONTAZER: Thank you. Can you hear me?

24           I'm Parvis Montazer, Consultant to Nye County, and  
25 I would like to take this opportunity to thank the Board for

1 providing the opportunity to make this presentation. I'd  
2 also like to extend Nye County's appreciation to DOE's  
3 cooperation in allowing us to get access to the site and  
4 invite us to a lot of closed door meetings as far as  
5 technical is concerned, and keep Nye County aware of what's  
6 going on in the project.

7           What I'd like to do is first apologize for not  
8 providing you with handouts. We'll mail handouts to you  
9 shortly after--by the end of this week. But I'd like to just  
10 briefly go over Nye County's plan on providing an early  
11 warning system, monitoring system, in conjunction with the  
12 Yucca Mountain study. And as part of that, we have a more  
13 extensive saturated stone study that I'll briefly go over.

14           Our saturated zone modeling effort that is ongoing,  
15 and I'm not going to go into the results because they're all  
16 preliminary at this point. The question is why Nye County is  
17 developing another model.

18           As everybody in this room, the basic primary  
19 interest is, Nye County also is interested in protecting the  
20 resources and lives in the county. The thing is that more  
21 often than not people in the county come and ask the  
22 representatives as to what if this, what if that, and what's  
23 going to be the impact. And we often times have to wait  
24 until we get the results from DOE, or pose those questions to  
25 DOE before we can provide a response to the citizens.

1           So we're taking this upon ourselves to basically  
2 recreate or copy, if you will, the DOE's saturated zone and  
3 unsaturated zone models into one combined model that we can  
4 basically run and do scenario analysis.

5           The flow of information is slow. That's not being  
6 critical on the project. That's the nature of the project,  
7 and we can't wait for a lot of the time for the final results  
8 to come out, so we have to--we want to be able to do a lot of  
9 the scenario analysis on a realtime basis. And as the  
10 project data comes in, we want to be able to evaluate these  
11 different alternatives.

12           And right now, there's really no monitoring system  
13 that's designed for the site, so we want to use this model to  
14 provide a tool for us to see if we can design our monitoring  
15 system, and at the same time, really find out where the data  
16 needs are.

17           Our approach as far as model is concerned, our  
18 philosophy basically is that the model is no substitute for  
19 the data, but it can be used as a tool to see where the data  
20 gaps are, and that's where we're heading.

21           Just to briefly show you, I don't know if the grid  
22 shows this, this is the same picture you've seen from  
23 D'Agnese's model. Our grid is more focused. The 32 VOC  
24 which we're going to be using basically is TOUGH code with  
25 some transport capabilities in it, and I'm not going to go

1 into detail on that. But it has a flexible mesh just like  
2 TOUGH-2, which is used for the unsaturated zone, and it has  
3 the advantage of being coupled with unsaturated zone readily,  
4 so we can basically decouple or couple the saturated zone  
5 flow with the unsaturated zone.

6           As you can see, we have emphasized our focus. This  
7 is a blow-up of the same mesh. You can see in the Yucca  
8 Mountain and the Amargosa Valley and down to Pahrump Valley,  
9 we are trying to emphasize the grid in that area where most  
10 of our interest is as far as what is going on with the  
11 system.

12           Based on this saturated zone investigation and  
13 reviewing all the information that's available, we have  
14 basically come up with a monitoring system, and the purposes  
15 are relatively clear. Number one is off-site hydrogeologic  
16 system not well known. As you heard from Zell, there's a  
17 relatively large data gap right south of Yucca Mountain, and  
18 the off-site ground-water monitoring programs are not  
19 satisfactory. Actually I said basically don't exist. And we  
20 don't see it really feasible for DOE to install an adequate  
21 monitoring system based on the economics of the project.

22           And last but not least, the ground water in the  
23 Amargosa Valley is becoming more and more valuable as the  
24 demand goes up.

25           This is our preliminary proposal for installation

1 of a phased drilling program. Yucca Mountain, this is the  
2 repository area, and we've designed this as phased, every  
3 year there will be two deep holes drilled and five shallow  
4 holes will be drilled to characterize the alluvium and the  
5 immediate bedrock. The deep wells are designed to as deep as  
6 the carbonate aquifer and figure out how the flow system or  
7 what's the stratigraphy and how the flow system is behaving  
8 in that area.

9           This well configuration is not cast in stone, and  
10 the reason we have it phased is we want to be able to, as we  
11 drill one hole, be able to predict and decide what we're  
12 going to do with the next hole. All the information that is  
13 going to become available from this is going to be used to  
14 planning the next location for the next hole. And we have  
15 plans and we have discussed cooperative efforts with the U.  
16 S. Geological Survey both on the geophysical activities and  
17 on the geochemical activities. All the samples that we  
18 collect will be available for analysis.

19           Just to show you the purpose of why we have the  
20 shallow and deep system is as far as monitoring is concerned,  
21 this is a cross-section north to south, going toward the  
22 Yucca Mountain, and this would be the Yucca Mountain area,  
23 and this is just a very simplistic scenario, what if you have  
24 a situation where basically either your pathway misses the  
25 deep holes--the deep holes are going to be spaced very far

1 apart, therefore, it's very easy for us to miss any narrow  
2 plume going through there, but once we get into the alluvium,  
3 they'll be dispersed enough for the shallow wells to be able  
4 to detect it.

5           Therefore, the primary detection mode is going to  
6 be the deep wells that are going to basically, the front row,  
7 if you will, and the shallow wells are basically backup just  
8 in case the deep wells miss the plume.

9           And that's all I have, and thank you.

10          PARIZEK: Thank you. Questions for Parvis? Parizek,  
11 Board. A question about your time frame for drilling; is  
12 that something that's likely to happen within a year or two  
13 years? And will it be quality control type well data which  
14 would be useful in licensing or support licensing data  
15 source?

16          MONTAZER: I'm going to attempt to answer, and I'd like  
17 Nick to jump in. Our hope is that to actually get funding to  
18 start this year, and the first set of holes we'd like to be  
19 able to install this year. And as far as the data becoming  
20 available for licensing, I can't--I'm not sure if that's Nye  
21 County's position to say whether that data is going to be  
22 usable for licensing, because the primary purpose will be the  
23 monitoring system, but the data will be quality assured. Nye  
24 County has got its own quality assurance.

25          Nick, do you want to mention--say something?

1           STELLAVATO: Nick Stellavato, Nye County. All the data  
2 we generate, we put in our own QA plans, and NQA1 program, so  
3 that we could take any data we do generate into the license  
4 if we needed to. So everything we do is NQA1, and it falls  
5 into NQA1.

6           PARIZEK: But it surely is data that would be useful;  
7 it's near the alluvium bedrock contact where a lot of action  
8 would occur from fracture flow domination in the bedrock all  
9 of a sudden to a more dispersed flow in the alluvium, so it's  
10 kind of an important data base, it seems like.

11          MONTAZER: Yeah, we understand that.

12          PARIZEK: John Czarnecki?

13          CZARNECKI: John Czarnecki, USGS.

14                 You mentioned that you would drill down to the  
15 first bedrock. Do you have any plans, say if you hit bedrock  
16 at a very shallow depth, to keep going and try to hit the  
17 carbonate aquifer in a number of these holes? We have an  
18 example of one of the holes which I think is planned to be  
19 converted to a multi-port observation well. That was  
20 Felderhoff-Federal 25-1. That hit the paleozoic carbonates  
21 at about 2,000 foot depth. Do you have like a target depth  
22 to work with, and if you have more depth to go, youi would  
23 drill that deep?

24          MONTAZER: Let me first clarify as far as hitting the  
25 bedrock, that was for the shallow wells that are going to be

1 in the alluvium. We'll try to penetrate the alluvium and  
2 hopefully select a thick section of alluvium and penetrate  
3 the upper 100 to 200 feet of bedrock, whatever that be, most  
4 like volcanics. The deep wells however, they are targeted to  
5 go at least 3,000 feet. If we don't hit the carbonates,  
6 depending on funding, we're going to go as deep--we want to  
7 make sure that we hit the carbonates, at least 100 or 200  
8 feet, and install--all of these are going to be on multi-port  
9 observation wells, and some of the wells, deep and shallow,  
10 we are going to plan to install a facility to be able to do  
11 pump tests. So there may be a possibility to do at least a  
12 single hole test, if not cross-hole testing in some of these  
13 holes.

14           PARIZEK: Thank you. I think we would say that any  
15 further questions for late this afternoon, we have again a  
16 public session. It's now time for beef tips over noodles and  
17 lasagna at the buffet, \$5.00.

18                   Can we come back by 1:30? That gives us an hour to  
19 eat, and we're then only 20 minutes behind schedule?

20                   (Whereupon, the lunch recess was taken.)

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AFTERNOON SESSION

7           PARIZEK: We have one minute to assemble for the  
8 afternoon session.

9           Putting the pieces of the puzzle together, the  
10 first presenter will be Robert Andrews. He's Deputy Manager,  
11 Performance Assessment Operations. He'll talk about the  
12 saturated zone flow and transport conceptual model and  
13 parameter issues affecting total system performance  
14 assessment. It's how much of what we heard this morning  
15 needs to be known about in detail, where this all fits in

16          ANDREWS: I'd like to walk through a few things today  
17 and of course put this all in perspective of why this is  
18 important from a performance point of view, and it's always  
19 easy to list the issues. I think we did a good job of  
20 listing the issues, and this morning, Dr. Parizek listed some  
21 issues when he started out. Those will be very similar, as  
22 you'll see, to a list of issues that come up later on here.

23           What we're maybe sometimes not as good at is  
24 quantifying those issues in a way that then can be made in a  
25 predictable evaluation forward looking mode, and then to

1 evaluate the consequences or the significance of those issues  
2 to help define additional data collection, et cetera. So I'm  
3 going to walk through very quickly from a performance  
4 assessment perspective the whole natural system, then zero in  
5 on just the saturated zone components, and then talk about  
6 some technical issues associated with its incorporation in  
7 performance assessment, and then a series of technical issues  
8 which then will feed into Kevin Coppersmith and our two  
9 experts, plus a follow-on discussion of things that were  
10 elicited in a series of workshops last summer and fall.

11           You can't have a PA talk without talking PA a  
12 little bit, just to make sure everybody understands that we  
13 have a full system here. This might be a little bit of a  
14 blow-up focusing in on one component--or all the components  
15 of the system, but here's all the engineered components of  
16 course which haven't been discussed at all today, all the  
17 other natural components in the unsaturated zone which  
18 haven't been discussed at all today, and what we've been  
19 focusing on is just what happened in the saturated zone.

20           Putting it in more of a modeling visual, we're  
21 looking at just this little bubble down here, which is in the  
22 saturated zone, the flow, and ultimately transport of  
23 radionuclides to some receptacle located at some distance  
24 down gradient from that.

25           The next slide talks about the natural system in

1 very, very general terms, but ultimately, what the saturated  
2 zone does is this very last bullet. It provides for a given  
3 release from the EBS from the unsaturated zone, provides some  
4 reduction by either dispersive dilution or retardation  
5 processes and some delay in the arrival time between the  
6 repository point to some distance down gradient.

7           The next slide really talks about what we want.  
8 Ultimately, and I think Bruce Robinson--well, I guess the  
9 last project speaker this morning, discussed this at some  
10 length. But ultimately, we want to take a release of  
11 radionuclide Y, so we look at some key radionuclides, the  
12 release of that from the base of the unsaturated zone as  
13 released into the water table and into the saturated zone,  
14 what is the time of arrival and ultimately the concentration  
15 of that radionuclide when it reaches any potential withdrawal  
16 wells if that's the ultimate point of discharge.

17           You know, our current understanding from what EPA  
18 is talking about and what NRC will probably ultimately  
19 implement is that it will be some kind of a well withdrawal  
20 type scenario, because it's closer to where we are now than  
21 it is to any point between here, which is about 50 kilometers  
22 from the site, back to any other regulatory type boundary.  
23 Whether that regulatory boundary is 30 kilometers or 5  
24 kilometers or 20 kilometers, which is the current bases for  
25 the calculations that are going on for the viability

1 assessment is TBD, of course, based on what EPA does and what  
2 NRC does.

3           The focus then is on a few key radionuclides, and  
4 these are no surprise because they've been coming out in  
5 other people's performance assessments, as well as project  
6 sponsored ones, are the very highly soluble and generally  
7 unretarded species, although Arend Meijer gave a talk this  
8 morning talking about the potential for technetium and  
9 neptunium to be potentially highly sorbed due to changes in  
10 geochemistry, and he even gave the potential for iodine on  
11 the organics in the alluvial system to also be sorbed.

12           So what I have here is generally they're treated as  
13 non-sorbed species and highly soluble, but may not be in fact  
14 the case in local spots in the saturated zone.

15           An important point I think somebody mentioned this  
16 morning is that the releases from the unsaturated zone are  
17 not point releases. They are in fact distributed releases.  
18 They are distributed over space, because it's a relatively  
19 large repository area, and they're also very distributed over  
20 time. The degradation rates of the engineered components of  
21 the system are time varying functions. Those time varying  
22 functions and the degradation mechanism and the transport  
23 mechanisms all tend to spread out the release that arrives at  
24 the water table in time. And, of course, as we've talked I  
25 think this morning, taking those releases and translating

1 them into concentrations at that 20 kilometer distance is  
2 also temporally and in fact spatially variable.

3           What we've assumed this might be right here, in the  
4 absence of EPA telling us where that well is, we say let's  
5 assume that well is in the zone of maximum concentration at  
6 that 20 kilometer fence. So regardless of whether or not  
7 that is exactly the maximum concentration or not, that's the  
8 assumption, and I think many of you have read what the NAS  
9 panel said. They had two kind of alternative models, one  
10 which had a stochastic kind of likelihood of interception of  
11 plumes, and the other one said no, make it simple, just  
12 deterministically assume you're going to hit that plume with  
13 that well. Don't take any credit for the likelihood of  
14 intersection or non-intersection of a plume. But that's an  
15 issue that's going to be discussed I think by our two  
16 experts, certainly an issue that came up in the expert  
17 elicitation.

18           Some major groupings of saturated zone flow and  
19 transport model issues or uncertainties, and these come from  
20 a lot of different places. NRC of course has reviewed this  
21 and they have issues or sub-issues associated with the  
22 saturated zone. The project has sponsored a number of  
23 workshops. We did go into the viability assessment. We  
24 said, well, let's get all the people together that know  
25 something about this, and ourselves come up with what we

1 think are the key issues that need to be addressed. And that  
2 does need to be addressed mean? It means through somehow,  
3 either in a sensitivity study or as part of an elicitation or  
4 direct incorporation in the viability assessment, we need to  
5 quantify and address the significance of these issues. And  
6 if that means for L.A. purposes going and collecting  
7 additional data, then that's what it will point to. If it  
8 means the significance is small and maybe you don't need  
9 additional data, and the sensitivity showed it was relatively  
10 insignificant, then you say, you know, no point in going on  
11 with significant additional data collection on issue X.

12           So this just more or less lists these issues. Some  
13 of them are really geologic issues. Some of them are flow  
14 related issued. You've talked a lot about both of these this  
15 morning. Some of these are more transport related, and some  
16 of them are more modeling related, coupling of the  
17 unsaturated zone and the saturated zone, looking at coupled  
18 effected, like climate changes and tectonic effects and  
19 thermal effects.

20           Another issue down here at the bottom is what kind  
21 of scenarios might be used to actually simulate the water  
22 withdrawal from the well. Does the well tap the whole  
23 aquifer? Does it tap the zones in the aquifer? What's the  
24 likelihood that it tapes a zone that has no contamination  
25 versus contamination? Those sorts of issues.

1           One of the things that came out of that workshop  
2 that we conducted in the spring of this year was more or less  
3 a series of activities to try to address in a quantitative  
4 fashion some of the sensitivities with the process  
5 understanding and look at alternative ways of modeling or  
6 alternative ways of addressing particular technical issues.

7           And so a series of studies in fact were conducted  
8 last fiscal year. Bruce this morning talked to you about  
9 this one. Bruce and Bill Arnold worked together. Bill will  
10 talk to you a little bit later about how the two zones are  
11 being connected effectively for TSPA purposes. You heard a  
12 lot of discussions already about the C-Wells and those data,  
13 and interpretations of those data are being used directly in  
14 the TSPA for the viability assessment.

15           Frank talked to you at some length this morning  
16 about the past and present, and a little bit about future and  
17 the climate impacts. You didn't hear about this one, but  
18 there have been other studies done by LBL to look at  
19 structural effects on flow.

20           Some of the things that Linda Lehman was talking  
21 about this morning have also been addressed by the project  
22 looking at structural effects and temperature effects on the  
23 SZ flow system.

24           All of those issues and all that knowledge was then  
25 kind of consolidated into I have eight, I think actually when

1 it was elicited it came out to be ten issues which were then,  
2 with all the relevant data that the project could bring to  
3 bear, or others could bring to bear, was given to a series of  
4 I think five experts for them to help us quantify the  
5 uncertainty in key aspects that we all agree were key aspects  
6 of the saturated zone flow and transport model.

7           Kevin is now going to walk through the process of  
8 that elicitation, walk through the results of that  
9 elicitation, and then you've asked two of the experts to give  
10 their own feedback and their own personal reflections, and  
11 hopefully you'll ask them the hard questions that you asked  
12 people this morning, too. That's what they're paid the big  
13 bucks for.

14           So with that, I'll stop, and if there's no  
15 questions for me--

16           PARIZEK: Wait. We have to at least allow for  
17 questions.

18           Any questions from the Board for Bob Andrews?  
19 Priscilla Nelson?

20           NELSON: And you can defer this to a later speaker.

21           I'm interested in the source term characterization  
22 for saturated zone analysis. Will that be covered in terms  
23 of what it looks like that's coming out of the UZ into the SZ  
24 in time?

25           ANDREWS: Will it be covered in here? No.

1 NELSON: Is that going to be discussed here?

2 ANDREWS: No.

3 NELSON: Like is Dr. Arnold going to discuss that today?

4 ANDREWS: He's going to talk the process of coupling the  
5 UZ transport model with the SZ flow transport model. Now,  
6 the output of that UZ transport model is a function of all of  
7 the engineered components of the system and the degradation  
8 of those engineered components and dissolution and transport  
9 in the engineered components of the system and transport in  
10 the unsaturated zone, which is another couple of days of  
11 talks, which we don't have right now.

12 NELSON: Okay.

13 PARIZEK: Alberto Sages?

14 SAGES: You have in your transparency Number 6, what do  
15 you exactly mean by source term? It says Y is determined by  
16 source term, and then EBS release and UZ transport--I thought  
17 that EBS release was--

18 ANDREWS: Yeah. I mean, the source term in that  
19 particular thing means, you know, the waste form, degradation  
20 of the waste form, the cladding, release from the package  
21 itself, and the EBS is the additional engineered components  
22 that may or may not be in the drifts.

23 SAGES: But they're also studied?

24 ANDREWS: They're all related to, yes.

1 SAGYES: Okay.

2 ANDREWS: Often we get a release at the edge of the  
3 drift, and that release at the edge of the drift is  
4 transported through the unsaturated zone, yeah.

5 SAGYES: Okay, thank you.

6 PARIZEK: Chairman Cohon?

7 COHON: Cohon, Board.

8 Is TSPA/VA done, frozen, in terms of what's in the  
9 model, both model structure and major parameter values?

10 ANDREWS: Model structure is for 95 per cent of it.  
11 There's a few--

12 COHON: What about with regard to saturated zone?

13 ANDREWS: It's frozen.

14 COHON: And in terms of what we're about to hear as the  
15 expert panel, did any of that influence the saturated zone  
16 representation in TSPA/VA?

17 ANDREWS: Yes. You'll hear that from Bill Arnold, I  
18 think.

19 COHON: Okay.

20 ANDREWS: How it was used.

21 PARIZEK: Other questions from the board? Staff?

22 (No response.)

23 PARIZEK: Okay, thank you, Bob.

24 Our next speaker is Kevin Coppersmith. He's vice-  
25 president with Geomatrix Consultants, and he's sort of been

1 the driving force behind this whole expert elicitation  
2 process. I call him Mr. Certainty, seeking project  
3 uncertainty in the program, and he's not looking for  
4 consensus, he'll tell us, but I see also an analog for Kevin.  
5 He's sort of like to the expert elicitation process, like a  
6 grape press is to wine making. He gets to squeeze the  
7 experts for their opinions and their uncertainties, and we'll  
8 see a couple of grapes after Kevin's presentation.

9 COPPERSMITH: Sometimes I think the expert elicitation  
10 process is sort of the project irritant. We irritate the  
11 technical PIs that are trying to get work done and milestones  
12 in, and we cause them to come and give a series of talks. I  
13 think Frank D'Agnese, for example, gave three talks in a  
14 single one of our workshops.

15 We have the experts who have to do far more than  
16 they would if they were on a peer review panel. They  
17 actually have to quantify uncertainties and go through a very  
18 torturous process of drinking out of a high powered fire  
19 hose, and that's very tough to do, and then others in PA are  
20 asking when are you going to get your results to us so we can  
21 use them in the viability assessment. So it is a real  
22 challenge, and I won't continue on with the wine making  
23 analog.

24 Let me go through in general the purpose, the  
25 objectives of these elicitations, and I want to make it very

1 clear there are a couple of issues, procedural issues, that  
2 I'd like to cover in the course of this as we go through it  
3 that I think are very important.

4           Number one, the goal of these elicitations in the  
5 saturated zone is one of a series of five elicitations being  
6 conducted for purposes of the viability assessment is to  
7 quantify uncertainties. So we're focusing in on a  
8 characterization of uncertainties. Now, that  
9 characterization can be quantitative in the sense of  
10 uncertainty in parameter values, or it can be more  
11 qualitative in terms of the relative degree of belief that  
12 exists in alternative conceptual models, or it can be much  
13 more qualitative than that just in terms of the overall  
14 conceptual model or important processes that might need to be  
15 considered in the process.

16           So this, to my way of thinking, is the focus. It's  
17 not to supplant data collection or other types of things, but  
18 to characterize uncertainties.

19           A panel of experts, we have members on this expert  
20 panel, as I'll show in a minute, who have been involved in  
21 the project to some extent, and we've had those who have not  
22 been involved in the project. The idea is, and the question  
23 always comes up why not just involve project experts. My  
24 definition of an expert is an acknowledged--an individual  
25 with acknowledged specialized knowledge and experience, and

1 that acknowledgment comes obviously from publications and  
2 other peer review types of things. The specialized knowledge  
3 and experience speaks for itself.

4           Obviously, we have those individuals on the  
5 project. There are experts. There's nothing special about  
6 that, other than the fact that by bringing people in from  
7 outside and focusing them on uncertainty characterization, we  
8 might have an opportunity to get a broader perspective, a  
9 better representation of the diversity of views that exists  
10 at some particular point in time. So that's not to say that  
11 there aren't experts within the project as well.

12           It is a snapshot of uncertainties. My view of  
13 life, if I can give it briefly, is that technical  
14 interpretations consist of two parts, data, plus judgment,  
15 and I think that data at any particular point in time,  
16 there's a ratio of data to judgment that go into the  
17 interpretation. I think there is uncertainty in data. Even  
18 if we have a hell of a lot of data for some particular  
19 aspect, we still have uncertainties, at least variability or  
20 dispersion and other measures. There's uncertainty in  
21 judgment. Alternative conceptual models might be an example.  
22 And ultimately, our responsibility for something like TSPA  
23 is to characterize the uncertainty in the interpretations.  
24 We do that by characterizing those uncertainties in the data  
25 and judgment.

1           The question often comes up where you do use the  
2 elicitation to supplant data, or in lieu of data, or don't be  
3 tempted by the possibility of being able to use elicitation  
4 to supplant data.

5           From my point of view, expert elicitation is the  
6 process of characterizing uncertainties in the  
7 interpretation, the degree to which at any particular time,  
8 the data to judgment ratio can vary. And we asked this panel  
9 of experts for that snapshot this summer, basically in the  
10 August, September time frame, and that was the point they had  
11 that they were able to look at the data, try to drink from  
12 the fire hose of information they heard from multiple talks  
13 and written materials to make that assessment. And it's a  
14 very difficult assessment to make.

15           This is part of a series of elicitations, and I  
16 think again the distinction may be for another talk to this  
17 group. This is very different from a peer review where  
18 you're asked to come in, talk about what's being done, why  
19 it's being done, grill the technical PIs and then talk about  
20 what should have been done or could have been done or will be  
21 done. These guys first have to make an assessment of  
22 uncertainty. To do that, they need to assimilate a huge  
23 amount of data in a small amount of time. We go through a  
24 process of characterizing those uncertainties, and then we do  
25 ask the question at the end what do you think can be done to

1 reduce uncertainties. And that's an opportunity for them to  
2 be as specific as possible about those types of activities  
3 that can be conducted. And we'll hear some about that in the  
4 discussions that follow me.

5           I should point out one thing that I've only read  
6 the written materials. The Board, as you know, brings the  
7 experts in, so we're not involved in that process. But  
8 sometimes we're questioned about whether or not a process we  
9 follow somehow biases or unduly affects the judgments of the  
10 experts, and we work very hard at not doing that, and I think  
11 good evidence of that is Lynn Gelhar's written comments where  
12 he basically draws us across the coals for some of our  
13 procedural aspects. So clearly, we haven't affected him in  
14 any way.

15           The steps that we follow, and again these are the  
16 steps we followed at other elicitations. This follows what's  
17 called a formal elicitation process, and it's not formal in  
18 the sense that we all were ties or we use a rigorous  
19 questionnaire type of approach that's very formalized. In  
20 fact just the opposite. Those of us who have been in the  
21 game here know within the jargon formal means that you  
22 basically have a set of steps that are followed. The NRC  
23 technical position on expert elicitation, DOE guidance that's  
24 been developed all specify this type of series of steps that  
25 deal with selecting the experts, carrying them through with

1 dissemination of data, discussion of alternatives,  
2 interactions at multiple workshops, going through an  
3 elicitation process, feedback, documentation. That's what we  
4 mean by formal as opposed to an informal process where it  
5 isn't clear quite who made that assessment, where the  
6 judgment came from, what the technical basis was, whether or  
7 not it was designed through uncertainty, and so on. Informal  
8 technical judgments are made all the time and are part of the  
9 process of evaluation. Formal allows this process to be more  
10 clearly defined according to these types of steps.

11           By the way, I was talking with Dick Parizek, and  
12 during the course of these workshops, I was sitting down and  
13 thinking about it. I think we've had on the order of 500  
14 talks, or so, and every one of the times I was the guy  
15 sitting there with the watch. So I know how horrible that  
16 process is, and I probably won't save you much time as we go  
17 through this.

18           This is the members of the SZ expert panel, again  
19 composed of a number of acknowledged experts, and some  
20 include information or past experience related to the  
21 project. Others have not been directly involved to any  
22 extent.

23           Let me just briefly go through. You have in your  
24 packages my viewgraphs obviously, and you can look at these  
25 in more detail, but let me just step through some of the

1 issues that we asked the experts to address. But remember  
2 that again we're looking for not only quantitative  
3 uncertainties in parameter values, and so on, but also  
4 looking at some of the conceptual issues, conceptual models,  
5 how these things should be developed. And some of the  
6 members of the panel are modelers themselves and spent quite  
7 a bit of time exploring the regional hydrogeologic framework  
8 model, looking at the way it couples or doesn't couple with  
9 the site model, some of those other detailed aspects of the  
10 process.

11           In terms of the conceptualization of SZ ground-  
12 water flow, a couple of important issues that were address,  
13 for example, the down gradient flow that we were talking  
14 about this morning, appear to be largely within the volcanic  
15 aquifer and the alluvium, not much evidence for actual down  
16 gradient flow within the carbonates. Highly permeable flow  
17 regime; channelization is a very important issue and we'll  
18 hear more discussion about that. It appears to be a highly  
19 interconnected system of faults and fracture system, again,  
20 consistent I think largely with the discussions that we heard  
21 this morning by the technical PIs on the project.

22           Multiple hypotheses have been proposed; large  
23 hydraulic gradient. I'd say the panel in general was split  
24 in terms of the importance of that feature. Two, saturated  
25 zone flow and transport issues. It obviously is an important

1 issue from the standpoint of our understanding of the  
2 regional hydrogeologic framework, but it's important to  
3 things like flux of the site or to down gradient flow and  
4 transport issues can be debated, and maybe there will be a  
5 little bit of discussion about that after me.

6           But basically, the panel boiled it down to two  
7 alternatives that actually are very close in my mind in terms  
8 of the causative mechanism for the large hydraulic gradient.  
9 We asked them for the possibility of short-term or transient  
10 changes, and those were deemed to be very unlikely.

11           The key issue of course is the flux at the top of  
12 the saturated zone beneath Yucca Mountain. It was defined as  
13 specific discharge, the product of hydraulic conductivity and  
14 hydraulic gradient. We're dealing with issues, scales that  
15 are the scale of the site scale model. John Czarnecki talked  
16 about on the order of a kilometer by a kilometer by perhaps  
17 100 meter type of scale in making this assessment. They  
18 considered the uncertainties in hydraulic conductivity that  
19 were presented to them, both in situ type single hole,  
20 multiple hole, laboratory analyses, and so on, in arriving at  
21 their assessments.

22           There's quite a bit of uncertainty in the hydraulic  
23 conductivity, particularly at these scales, and basically  
24 we're dealing with sort of effective of bulk type of  
25 assessments over those scales. And of course because of

1 those scales, the C-Wells data and other types of field tests  
2 that deal with characterization of the scale you're asked to  
3 make the assessment were deemed to be very important tests,  
4 and I think we'll probably hear more about the importance of  
5 those tests and other types of tests that can be conducted  
6 that are similar.

7           Velocities and porosities were provided by some of  
8 the experts, average linear velocities on the order of meters  
9 per year, with a good healthy range, and also some of the  
10 kinematic porosities, again a range of values.

11           The influence of climate change was discussed.  
12 Again, this is one that's perhaps less quantitative or  
13 qualitative, what do you expect to happen. Some of the  
14 evidence, geologic and otherwise, for past water table  
15 changes was deemed to be a reasonable way to estimate the  
16 potential for future water table rises beneath the site.  
17 Evidence was presented for past water table changes due to  
18 glacial episodes on the order of 80 to 120 meters. That  
19 seemed to be reasonable based on the data and presentations  
20 that were made to the panel.

21           We also asked them about the problem or the issue  
22 of transient glacial periods. Could this likely lead to  
23 different flow patterns or different types of processes that  
24 might perhaps affect dispersion and dilution. And there's  
25 some disagreement on that, and maybe I'll talk a little bit

1 about that, but whether or not in fact that climatic change  
2 condition, there will be long-term transients, but whether or  
3 not they're short-term enough to lead to true changes that  
4 would lead to more of a dispersion type mechanism, there's  
5 kind of a split on that issue.

6           Let me show one example of just some of the  
7 assessments that were made for, for example, for specific  
8 discharge, Shlomo Neuman dealing with the issue of specific  
9 discharge. We have some uncertainty in the hydraulic  
10 gradient, but most of the uncertainty in this assessment  
11 comes from uncertainty in hydraulic conductivity of the lower  
12 volcanic aquifer. And this is, for example, an example of an  
13 assessment that was made where he specified a particular type  
14 of distribution and the parameters to that distribution. In  
15 other cases, point estimates were made, cumulative  
16 distribution and functions and so on.

17           If we put those together, I want to use this just  
18 as an opportunity of showing where we have multiple  
19 assessments of a particular parameter value, and there  
20 actually aren't very many that we made in this elicitation,  
21 that we have this type of spread, expert to expert types of  
22 distributions, and the aggregate distribution that's shown in  
23 here in dark basically incorporates and treats all the  
24 experts equally and aggregates through a summing process  
25 across the CDFs.

1           Now, there's an opportunity, people have asked the  
2 question about what about if you have very few respondents,  
3 you have, for example, in sorption coefficients, we have one  
4 person making an assessment, in other cases, maybe two people  
5 have made an assessment. We're after uncertainty and we're  
6 after--there's some component of expert to expert, what's  
7 called diversity, that we're trying to capture. Obviously,  
8 in the process, if we're not--if we have one person or two  
9 people responding, we don't claim that that provides the full  
10 range of diversity that we're after.

11           These are not point estimates. We're not asking  
12 individual experts to be a proponent basically of a single  
13 view. We're asking them all to represent a range of views.  
14 But nevertheless, the law of low numbers comes into play.

15           In these cases, we use the information that comes  
16 from elicitation to supplement characterizations of  
17 uncertainty that are made from the PA anyway. So the TSPA  
18 has to characterize uncertainty in all of its input  
19 parameters in one way or another, the degree to which the  
20 elicitation can help with that process. If it provides only  
21 a qualitative assessment or provides just one or two  
22 distributions, that may not be sufficient to characterize the  
23 uncertainty. It will be used as a supplement; the  
24 uncertainty assessment will be documents in the TSPA.

25           Just a couple more. I need to finish. By the way,

1 Dick, in every one of those talks, everyone promised they  
2 would be--oh, this is going to be quick and I'll be done way  
3 under my allotted time. 90 per cent of time they're wrong.

4           Conceptual models. Again, this deals with the  
5 transport issue. I think most of the discussion here is  
6 similar to the types of discussions that Bruce Robinson and  
7 others dealing with the transport problems, there's agreement  
8 there, but I think in general across this panel, it was felt  
9 that in fact the proper way a conceptual model for the down  
10 gradient flow is one that is more contained. It likely would  
11 be within flow tubes. This is a highly permeable type of  
12 flow system, and the scales that we're dealing with, in fact  
13 there are a few mechanisms that will lead to substantial  
14 mixing or dispersion along those flow tubes out to distances  
15 of 5 to 20 kilometers, or so. And I'll leave some of that  
16 discussion to the presentations by Allan and Lynn.

17           The same thing with dilution factor. When we deal  
18 with regional distances, again we're dealing with the scales  
19 that are appropriate to scale the modeling. We're dealing  
20 with dilution factors on the order of about ten, perhaps with  
21 a range, but again very little, in my mind, very little  
22 transverse dispersivity is assessed.

23           Now, to show just again, here's an example of a few  
24 of the assessments of the dilution factor, quite a range, and  
25 that range of uncertainty that could be used in the model.

1           Just a couple others, and then I'll end. We asked  
2 about effective fracture density, some of the transport  
3 parameters. Again, when we got into the discussions of  
4 things like Kd values for particular radionuclides, our  
5 hydrochemist, Don Langmuir, basically was the one who  
6 provided the most information related there, the only  
7 quantitative information. And, again, that will then be used  
8 to supplement the assessments that the project makes of Kd  
9 values. But basically, he made the point that, and all of  
10 the experts really made the point that the issue, a key issue  
11 is the residence time in the matrix, and again there were  
12 discussions about this this morning, the degree to which the  
13 C-wells data shows that type of dual permeability type of  
14 behavior is very important.

15           In fact, do we have field evidence that would allow  
16 us to deal with how much time or whether or not significant  
17 portions of the flow reside in the matrix for any appreciable  
18 period of time. That's where a lot of the reactions will  
19 occur and a lot of the retardation.

20           Some of the issues, and perhaps, Lynn, you'll  
21 comment on this, has to do with the use of the laboratory  
22 sorption data. There were some questions about its  
23 usefulness. It obviously is some of the best data that  
24 exists. But how representative of the field conditions is it  
25 in the types of tests that are carried out?

1           Let me just jump to the end, because again, one  
2 thing I've found through the course of these elicitations is  
3 that the recommendations are the areas that experts love to  
4 respond to the most, because it's an opportunity for them to  
5 focus back on the uncertainties and say that not only is this  
6 an uncertain quantity, but here's something you can do about  
7 it specifically.

8           So I just put those into categories that deal with  
9 the recommendations. In fact, in elicitation summaries, the  
10 experts are very specific about the types of tests that could  
11 be carried out to help reduce uncertainties. They deal with  
12 multi-hole types of tests, in situ types of tests that  
13 provide the proper scales for making the measurements,  
14 interference tests at C-Wells complex and recommendations  
15 there. Again, the issue of fault zone properties is one that  
16 is very important. How do faults, what are the hydraulic  
17 properties specifically of fault zones, how important are  
18 they to the flow regime? It's a very important issue, and  
19 the more that can be done in situ, the better off it will be.

20           Calibration and coupling of the regional site scale  
21 models, a very strong emphasis, particularly for someone like  
22 Shlomo Neuman who feels that they need a tighter coupling to  
23 make them usable. And, again, a few of the experts dealt  
24 with the issue of ground-water chemical data, potentially  
25 additional isotope data of the type you heard about this

1 morning.

2           It's all in there and open for questions.

3           PARIZEK: Thank you, Kevin. Questions from the board?  
4 Alberto Sagnes?

5           SAGYES: Yes. Sagnes. How do you handle aggregation of  
6 magnitudes which are given on a--like the example that you  
7 show here with the volcanic aquifer velocity? Do you handle  
8 those things linear or logarithmic?

9           COPPERSMITH: They're handled all--you put them all into  
10 whatever space you want to have them. If they were collected  
11 in linear space, which they often were--actually, this panel  
12 was more logarithmic space. We can combine them that way.

13          SAGYES: But then you combine them logarithmically?

14          COPPERSMITH: If they've been provided that way. We're  
15 dealing right now with equal weights. We don't have any  
16 differential weights expert to expert in the combination  
17 scheme. They are all equal. The way we deal with that in  
18 terms of numbers is if a particular expert does not want to  
19 respond to an assessment, it's out of their field of  
20 expertise and so on, then we don't have an assessment for  
21 them on that issue. So we're not combining that.

22          SAGYES: Well, if an expert says point one and another  
23 one says one, do you average it as .3, which would be the  
24 logarithmic average, or do you average it as .5 or point

1 whatever?

2 COPPERSMITH: It's linear.

3 SAGYES: Linear average. If you ask for pHs, for  
4 example, one says pH of 4, one says pH of, say, 5, the pH  
5 average would be--you can average 4.5, or you can average to  
6 something else, depending--

7 COPPERSMITH: We do it linearly. The other important  
8 thing is that you'll see on all these, that we show the  
9 assessment that each individual expert makes, because that is  
10 important. But, you know, getting to the logarithmic,  
11 earthquake magnitudes for example, Richter magnitudes and all  
12 the magnitude scales are logarithmic one way or another, and  
13 they're all done linearly. It's clear when you have the  
14 assessment, individual experts also, you can see what their  
15 actual assessments were.

16 PARIZEK: Chairman Cohon?

17 COHON: Cohon, Board.

18 I also continue to have questions about the  
19 combining process, and I'm sure there are questions that I'll  
20 have forever, and I'm sure there are questions you have about  
21 it as well. But I want to try to get a sense of threshold,  
22 that is, it's clear that one expert is not enough, and the  
23 more experts the better, up to some number I guess where it  
24 becomes difficult to handle. What I'm really curious about,  
25 and it came up I guess in the unsaturated zone process as

1 well, is when you have a relatively small number of experts  
2 who sharply disagree, in that case, the combining leaves one  
3 really kind of queasy, at least me.

4           Here's another example, and we'll wait for the  
5 individual experts to talk. I want to hear especially what  
6 Allen Freeze has to say about it, but when you have  
7 distributions which almost don't overlap at all, but instead  
8 of making this, say, instead of preaching, let me try to pose  
9 a question, is there some threshold of disagreement beyond  
10 which you'll want to step back and said wait a minute, I'm  
11 not comfortable here combining them at all?

12          COPPERSMITH: Well, there's a whole--there's different  
13 ways to answer that. One, though, is basically you're  
14 falling into a couple of camps and there's a bimodal type of  
15 distribution and you're basically combining such that the  
16 application, the use is going to be of, say, a mean value,  
17 then you're going to be wrong, by definition, you're going to  
18 fall between the modes of the distribution and it's going to  
19 be a problem.

20           These distributions are using the entire  
21 probability distribution, the entire combination. I don't  
22 think that there's any plan in PA to basically use some  
23 single value to represent the aggregated combination of  
24 assessments that are made by the experts.

25           But the other issue sort of how many, you know, the

1 difference between one, two, three, four, to move up, how  
2 much more do you gain, has been examined. And normally the  
3 measure, or one measure that we've done in the past is to  
4 look at the contributions to uncertainty. If you have a case  
5 where you have a large number, say you have ten, like we had  
6 in the volcanic hazard, and the question came up how many did  
7 you need to have to capture essentially all that uncertainty  
8 or diversity, you can work your way back down through a  
9 random sampling process or bootstrapping process, down to  
10 eight, nine, and so on, and look at the way, say, the 90th  
11 and 10th percentiles come in. And what you see as you do  
12 those, if they don't come in significantly if you get down to  
13 numbers of like five or four, and there's right around at  
14 that point, you begin to really lose a significant part of  
15 the total uncertainty, say you lost 30 or 40 per cent of the  
16 total, and that's one way to do a test of that. I know the  
17 NRC has done similar types of tests when they were dealing  
18 with the issue of do they have enough experts.

19 COHON: But in the previous case, when you seemed to  
20 have two distinct modes, and you said by definition, it would  
21 be wrong for you to take a mean value, what would you do in a  
22 case like that?

23 COPPERSMITH: I would take the total combined  
24 distribution, and not a central value, and would display the  
25 individual assessments by the experts, so that anyone looking

1 at the data can see where the mass of the data actually lay,  
2 and here's what the aggregate looked like.

3 COHON: But wouldn't your statement about the average of  
4 two point estimates being wrong apply to two distributions as  
5 well? That is, wouldn't a combined distribution in some  
6 sense be wrong?

7 COPPERSMITH: Well, it might not be wrong in the sense  
8 it depended on the application. If you wanted an assessment  
9 of hazard or something, then it might in fact be correct.  
10 But if you at some point need to dissect the details of a  
11 problem and see what the contributors were, you would need to  
12 see the details of those modes of the primary distribution at  
13 one end.

14 COHON: Okay, thanks.

15 PARIZEK: Other Board questions? Staff?

16 (No response.)

17 PARIZEK: We thank you very much, Kevin. And we'll  
18 continue with two of the five experts that made up the panel,  
19 Allan Freeze being the first. We'll call him a grape in this  
20 regard. He comes to us from Canada. He's had a  
21 distinguished career and continues to have one as owner of  
22 his own company, Allan Freeze Engineering, Incorporated.  
23 Before that, he was at the University of British Columbia,  
24 and before that, University of California Berkeley. Allan,  
25 we could say he's a straight shooting Canadian, but he talks

1 fast and he'll get his in in a short time period, I think.

2       FREEZE: Well, maybe I'll start with my definition of an  
3 expert. My definition of an expert is somebody that can say  
4 whatever he wants without any responsibility for all the  
5 trouble he causes every all around him.

6           In my case, coming from another country, I'm kind  
7 of doubly protected, because I don't even pay the taxes that  
8 this might lead to.

9           You're not going to hear anything really new from  
10 me. I think everything that I'm going to say has been said  
11 by somebody else here in these last couple of days.  
12 Basically, we were asked our opinions. We were given all  
13 these possibilities, and asked in a sense which ones we  
14 believed. So, you know, I could give this talk by saying,  
15 well, I agree with Frank on his third slide and I agree with  
16 somebody else on their fourth slide, and Item 2-B of somebody  
17 else, but I'm kind of going to go through that, so I hope  
18 you're not looking for some kind of whole new ball of wax.  
19 You're not going to get it. You're going to get all the same  
20 ideas and me saying, well, in my opinion, you know, it's more  
21 this way than that way.

22           The issues that I thought I would try and zero in  
23 on today are the role of faults, the large hydraulic  
24 gradient, and the potential dilution, those three. And in a  
25 short time, I think those are three of the more important

1 ones. I'm not going to say too much about the transport  
2 parameters, although I will mention my thoughts about  
3 retardation kind of in passing.

4 I think you have to start if you're going to talk  
5 about the role of faults, you have to start by thinking about  
6 the hydrogeology on the scale of the site itself. And,  
7 again, we've heard a lot of talks about this, but I just  
8 wanted to tell you where I'm coming from.

9 I see the different scales, the regional scale, the  
10 site scale and the sub-site scale, and each of the diagrams  
11 you might put up would look a little bit different. Here's a  
12 kind of a very simplified diagram of the regional scale,  
13 representing the lower carbonate aquifer, the volcanics up  
14 above and the alluvium down in the end.

15 You'll learn most of us believe that the flow paths  
16 from Yucca Mountain are likely to stay in the volcanics and  
17 go into the valley fill, but clearly, there's some  
18 possibility that the carbonate aquifer could be a pathway,  
19 although not perhaps very likely. But I agree with the  
20 people that say that it's an important controlling feature on  
21 the entire hydrogeology of the system.

22 You can move down a scale, and we've all seen this  
23 diagram, and now we have those two sets of names that we have  
24 to be thinking about all the time. The one set of names are  
25 the formations, the Topopah Springs and the Prow Pass, and

1 all that sort of thing. On the other hand, the  
2 hydrogeologists have divided these into the upper volcanic  
3 aquifer, which is basically the Topopah Springs, the upper  
4 volcanic confining unit, which is basically the Calico Hills,  
5 lower volcanic unit and lower volcanic confining unit.

6           Much of what we talk about today is going to be  
7 concerned with the lower volcanic aquifer, the Bullfrog Tuff  
8 in particular, and the issue then is kind of what is the role  
9 of the faults in the movement of water through this system.  
10 We have to move down yet another scale I think before we can  
11 really begin to answer that question totally, and here's some  
12 logs which I'm sure you've seen before from the C-Wells,  
13 which show that there's a lot of internal basically horizontal  
14 stratigraphy within each of these formations, these geologic  
15 formations, and within each of these hydrogeologic units such  
16 as the lower volcanic aquifer.

17           There are welded and non-welded embedded sections,  
18 and I think all of us that have seen all this data over the  
19 years have slowly been educated towards the fact that it's  
20 the bedded--it's the fractured--let me start again--the  
21 fractured, welded, middle portions of the flows that  
22 represent a potential horizontal high permeability aquifers.  
23 That's the stratigraphic control on things.

24           So when I picture a leak happening to one of these  
25 canisters some century down the road, I picture it entering

1 into some place in this whole system, but first of all, it  
2 has to get to here, this highly fractured, welded,  
3 potentially migration hosting horizontal stratigraphy. So  
4 the first step is it's kind of got to make its way there.  
5 Then it's liable to flow very quickly. But then of course  
6 it's going to encounter one of these faults which block these  
7 things all off into these little blocks. And the faults  
8 themselves then, we start thinking about them, and they also  
9 occur at several different scales.

10           At the regional scale, we have these big vertical  
11 faults, basically north-south trending, Solitario Canyon,  
12 Ghost Dance, Bow Ridge Faults, spacing about a kilometer,  
13 laterally continuous for hundreds of miles, offsets of  
14 hundreds of meters.

15           The next scale down, which you might see in a map  
16 like this one, are these ones in red, and there's even been  
17 some suggestion that the Sundance Fault down farther this  
18 way, a little different orientation, likely to have a little  
19 different properties. They don't go for as far and their  
20 offsets are more on the order of, say, tens of meters.

21           So, once again, we could picture that particle of  
22 water then having kind of gone through the matrix it enters,  
23 this sparsely fracture rock, getting into the Bullfrog,  
24 heading off somewhere, hitting one of these two different  
25 types of faults, and depending on which type it is, it might

1 be a bigger or smaller event in its pathway.

2           If it hits one of the big ones, does it then just  
3 sail right off the site or not, or what do we expect those  
4 big ones to look like? Now you're starting to get some  
5 personal opinion. I have a fair bit of background in the  
6 geotechnical world in my experience, and have looked at a lot  
7 of faults around dam sites and things like that. The faults  
8 that I've actually seen, that I've actually mapped and looked  
9 at in the field, often are this kind of layering, if you  
10 want. I mean, this makes sense from a structural point of  
11 view, from a tectonic point of view, that when the faults  
12 move, on the one side--there's a moving side and a stationary  
13 side very often--on the moving side, you might get  
14 brachiation of the rocks. It breaks up. You get fracture  
15 and you get higher permeability, a plane of high permeability  
16 parallel to the fault.

17           On the other hand, on the stationary side, it tends  
18 to grind the stuff away. And if the formations that it's  
19 grinding on have a lot of play, and that kind of material  
20 that can be ground into gouge, then you get gouge along that  
21 side.

22           So there's a question of whether these faults are  
23 high permeability or low permeability. I suspect most of  
24 them are both, that they have high permeability parts and  
25 they have low permeability parts, sometimes both in the same

1 place. But in other cases, I expect both those events to be  
2 patchy, too, because picture that the faults are actually  
3 breaking down through that cross-section of stratigraphic  
4 formations, some of which are highly brittle and some of  
5 which are more likely to create gouge.

6           So I picture on that plane, a kind of a  
7 checkerboard, if you want, of high and low permeability  
8 things, but somewhat layered, so therefore somewhat  
9 anisotropic in the plainer dimension, high permeability  
10 parallel to the plane, low permeability across the plane.

11           Now, that's all kind of a conceptual model that I  
12 think should be built into these models as best can be done,  
13 but many of the models so far that have been developed by  
14 USGS are at a bigger scale than that.

15           The newest model that's sort of appearing, at least  
16 just appeared on my desk, is the one from Berkeley Labs.  
17 It's called the S-4 Zedd model. I don't know what that  
18 stands for, S to the fourth Zedd--or Z, I should say.

19           What does it stand for, Dwight?

20           HOXIE: Yeah, it stands for the sub-site scale saturated  
21 zone model.

22           FREEZE: There we go. Okay. You know, I gather that  
23 Bruce Robinson was also using a model of that scale, and I  
24 think it's at that scale that we could begin to think about  
25 introducing some of these things. Clearly, they can't be

1 introduced on huge 1.5 kilometer, 500 meter thick blocks.

2           But to my mind, when we're starting to think about  
3 travel times and dispersions and dilutions and all that sort  
4 of stuff, we have to think of the role of faults in a  
5 somewhat more complicated manner along the lines that I've  
6 been trying to describe.

7           The faults and the fractures are often stratabound.  
8 The fracture density depends on the unit. Hopefully, you  
9 can read the rest of this stuff as we go through this.

10           Now, I think there is some evidence that the major  
11 and secondary faults do act, you know, as high permeability  
12 pathways in the direction of flow. This is Linda Lehman's  
13 diagram which she showed you earlier today. I think it has  
14 some merit. It doesn't surprise me that there might be  
15 things like that, that the equipotential lines would be  
16 splayed out and around these various faults.

17           As you can see, if this were the case, as she has  
18 drawn it, then it means the flow is in toward these things,  
19 and there's a flow down this way. I wouldn't be surprised to  
20 see one come this way and go off that way. That would be  
21 that it's coming in from one side and not the other perhaps.

22           So, you know, I think these faults certainly play a role.

23           There's abundant evidence that most of the in-flows  
24 to drill holes, this is just one of the C-Wells, that the  
25 flow coming in comes in in very bounded locations, and it's

1 exactly usually where those welded middle Bullfrog  
2 stratigraphic units are, or where faults cross the system.

3           So this comes up over and over again. You get the  
4 flows coming in. You get the temperature moving. I think  
5 there's a lot of evidence to suggest that there's  
6 concentrated and focused flow. But I don't picture it, Dr.  
7 Craig, as being one of these--you know, as being open  
8 pathways or something with space in between. I think of them  
9 as being shear zones, fracture zones of some width of higher  
10 permeability with a lot of this high/low checkerboard  
11 permeability controlling it.

12           There's also evidence that they act as low  
13 permeability barriers in some places. This is a diagram that  
14 George Barr showed to us. I don't know if you can make it  
15 out. I just copied it from him. This is supposed to be the  
16 Solitario Canyon Fault over here, and there appears to be a  
17 drop in head across the Solitario Canyon Fault, which implies  
18 that it's some kind of a linear barrier parallel to its  
19 plane.

20           On the other hand, we have all this other evidence  
21 that they act as conduits parallel to their plane. I think a  
22 lot of it of course has to do with what direction the  
23 gradient is going at that point in time.

24           He had also kind of hypothesized some other drops  
25 up to the north that might account for the large hydraulic

1 gradient. Those are obviously more contentious.

2           So in summary then of the sort of my opinions, if  
3 you want, about the fault zones is I think they're a very  
4 important feature, together with the welded highly fractured  
5 Bullfrog. I think that the flow paths will be ones that  
6 angle their way down through these things. I think any given  
7 flow, too, will experience a large variety of different  
8 hydraulic conductivity domains in its path. I doubt very  
9 much if there are high conductivity conduits that take you  
10 from point A all the way down to Amargosa Valley, just  
11 shooting it down at the highest possible permeabilities we've  
12 ever measured. I think that's highly unlikely. I think the  
13 flow paths would experience a lot of different  
14 permeabilities.

15           The stratigraphy then across the faults I think  
16 would be anisotropic. The stratigraphy itself I think would  
17 be anisotropic horizontal to vertical, and the faults  
18 anisotropic planer to cross-planer.

19           Some of the calibrations that were carried out with  
20 this new S-4Z model showed that the Solitario Canyon Fault  
21 could be calibrated as a low permeability unit, and the other  
22 faults as high K units. That sort of thing wouldn't surprise  
23 me, but I suspect it's somewhat more complicated than that.

24           Linda Lehman also drew attention to this paper by  
25 John Bredehoeft, which appeared in WRR last year, which seems

1 to me to have merit, where he's used these earth ties to try  
2 and back out a calculated value for fault permeabilities for  
3 the faults that go down into the carbonate aquifers. And he  
4 came up with a number that's about an order of magnitude  
5 higher than the tuffs aquifers that overlay them. So, again,  
6 he's starting to get some ballpark figures, but these are  
7 going to be among the higher permeabilities.

8           So that's what I was going to say about faults, and  
9 I'll be open for questions later.

10           The next topic is the large hydraulic gradient.  
11 Maybe I should preface all this by saying I suppose some of  
12 the things I'm saying, my opinions will be popular in the  
13 program and some of them will be unpopular. I don't know  
14 where that one on faults stands.

15           This next one I suppose is going to be popular  
16 because I'm one of the people that doesn't think the large  
17 hydraulic gradient is all that important. First of all, of  
18 course we draw attention to the fact that there's a lot of  
19 large hydraulic gradients all around this area. They're a  
20 feature of the hydrogeology of this basin and range area.

21           The one that we're looking at is this one, but  
22 there are lots of them all over the place. So they probably  
23 share some kind of a common cause, in my opinion.

24           The second point I would make is, and this is just  
25 a cross-section taken from the paper by Fridrich, et al, is

1 that the so-called large hydraulic gradient is not a huge  
2 thing, you know. It's just a somewhat higher gradient. It's  
3 actually, if we believe it's a fully saturated situation,  
4 it's just a slightly larger slope to the water table. I  
5 don't even like the term large hydraulic gradient too much,  
6 because we don't really know what exists down three  
7 dimensionally beneath it. It's a somewhat higher slope to  
8 the water table, and in actual fact, it's coupled with a less  
9 than average slope east of the Yucca Mountain site.

10           So the real question in my mind isn't where did the  
11 large hydraulic gradient come from; it's why is there this  
12 break in water table slope just at the north end of the Yucca  
13 Mountain site. One might have expected that it would have  
14 been more even right across the whole thing. You know, in a  
15 certain sense, it's not that big a deal.

16           Nevertheless, there has been mentioned a couple of  
17 different interpretations, a saturated flow system or an  
18 unsaturated or a perched flow system, let's call it, and I  
19 just want to make the point that the configuration of the  
20 water table beneath the land surface any place in the world  
21 is a function of the topography, the recharge patterns and  
22 the geology, the hydrostratigraphic units and the structural  
23 features.

24           The topography here steepens to the north. The  
25 recharge increases to the north. So even if there was no

1 geology at all, one would expect the water table slope to  
2 increase to the north in this area. And over here, I've  
3 tried to show you what these numbers look like. The  
4 topographic gradients change by an order of six times kind of  
5 thing, you know, as you move up these hills. The mean annual  
6 precipitation changes tremendously. The calibrated regional  
7 model suggests that the recharge should increase by maybe a  
8 factor of ten or something as you go up there. So there's  
9 lots of reasons for the water table slope to become steeper,  
10 but perhaps not this much steeper, and I think perhaps you do  
11 need to have some geological control on this.

12           Bill Dudley presented to us in the elicitation a  
13 tremendous summary of all the possible geologic arrangements  
14 that could lead to this. But just for the purposes of a  
15 meeting like this where not everybody is a hydrogeologist, I  
16 think they can be sort of simplified down to about three, and  
17 that's the three I've shown here. Some kind of a near  
18 vertical low permeability structural feature, and that was  
19 mentioned today, John Czarnecki made the point that he would  
20 have to introduce such a thing into his model in order to  
21 calibrate the heads.

22           Another possibility is a near horizontal low K  
23 feature, that should be stratigraphic feature. And, in fact,  
24 we have such a feature at the site right at the right  
25 location, and it's the Calico Hills formation. I'll keep

1 this diagram out.

2           But as you can see in this somewhat simplified  
3 again version of the geology, the water table comes across  
4 just kind of under the Calico Hills, and then at some point,  
5 it cuts up across the Calico Hills. That makes sense,  
6 because the Calico Hills is a low K horizontal aquitard, and  
7 we'd expect the water table to be steeper as it cuts across  
8 there, and then maybe flatten out again when it gets up to  
9 the top.

10           So to my mind, the one in the middle of this  
11 diagram may be the most likely one. One could also get this  
12 by some kind of a deep drain, for instance if the carbonate  
13 aquifer in some sense pinches out there or there's some  
14 portion of it pinches out or something, that could create a  
15 water table rise up above. The water table can kind of feel  
16 what's happening down below.

17           But I think the more likely of these is the one in  
18 the middle with the Calico Hills acting like this. And the  
19 point I want to make is what is the difference between a  
20 fully saturated system and a perched system? Well, if this  
21 system, the way I've drawn it here, I would imply it's fully  
22 saturated and the water table goes up across there like that.

23           The other possibility is that this water table up  
24 at the top here kind of comes right out to the edge, creates  
25 little springs there, and this water table then would come up

1 to here like this, and these would then join up across this  
2 way. It would be kind of an upside down water table, if you  
3 want, and in the middle here, would be an unsaturated wedge  
4 of rock with a saturated zone up here, and the fully  
5 saturated zone down here.

6           The question I would ask is what are the moisture  
7 contents likely to be in this unsaturated wedge that lays  
8 between these two saturated portions? I believe that it  
9 would be very highly saturated, almost saturated, in fact.

10           So my argument is that the difference between the  
11 two models, if you want to call them that, is not all that  
12 great. In one case, you have a water table that goes up like  
13 this, and the pores are 100 per cent filled with water, and  
14 in the other case, you have an unsaturated wedge and the  
15 pores are 95 per cent filled with water.

16           You can ask me questions about that if that's not  
17 clear.

18           So in my mind, the implications for the total  
19 system performance analysis are similar for both of the  
20 systems. I can't see answering the question as having a huge  
21 implication for the millirems per year that come out down in  
22 the Amargosa Desert.

23           Whether perched or saturated, the large hydraulic  
24 gradient is simply a manifestation of the local flow system  
25 controlled by the interactions between the topography,

1 geology and recharge. It's not a cause for alarm, in my  
2 opinion.

3           The likelihood of a break-through of water, dammed  
4 in some sense behind the LHG, to my mind, is zero. It's just  
5 not the way hydrology works. And I really can't think of any  
6 long-term transient readjustment of gradients that is likely  
7 to occur, even under some kind of tectonic influence.  
8 There's just a lot of controls on that keeping it up there.  
9 I just don't see it as a big deal.

10           In my opinion, the impacts on total system  
11 performance assessment would be much greater from the  
12 repository heating on the unsaturated and saturated  
13 hydrologic regime, or even on increased future pumping down  
14 in the Amargosa Desert, which will introduce transients into  
15 the flow system at the downstream end that could have quite  
16 an influence on travel times and things. To me, those two  
17 issues are much larger in scope.

18           Okay, to move on to the third issue, the third  
19 issue was the dilution issue. And of course the dilution  
20 issue requires that we first think a little bit about the  
21 flow net, exactly what it looks like. The models have  
22 provided us with a pretty good idea of what it looks like,  
23 but you can get some ideas of what it looks like just by  
24 thinking about it on the back of an envelope and scoping  
25 calculations, and so on. And for that reason, I wanted to

1 put up this little diagram. This is again of that same sort  
2 of location, again, a very simplified version of the geology  
3 showing the upper volcanic aquifer, the upper volcanic  
4 confining unit, that's the Calico Hills, the water table  
5 going across it, and in this case, I've favored my own  
6 interpretation, which was a bit of a minority interpretation  
7 on the panel, that it's probably fully saturated. If it  
8 turns out to be perched, I won't be embarrassed. I gave it  
9 30 per cent or something chance of being perched. I can live  
10 with that.

11           The point I wanted to make here is this one  
12 measurement of hydraulic head down in the carbonate aquifer  
13 at UE-15p, Number 1, is made right down here, and it's around  
14 750 meters, I don't remember the exact number, but that one  
15 hydraulic head point constrains the flow net tremendously for  
16 the whole system. One measurement is worth a lot. There's a  
17 lot of talk about we need a lot more of these measurements.  
18 That's probably true. But that one measurement, if it has a  
19 750 hydraulic head, there has to be an equipotential that  
20 goes from that point up to where the water table has an  
21 elevation of 750, and the only way you can draw that is  
22 somehow like that.

23           It's going to be more or less vertical across the  
24 aquifer and much more sloping across the aquitard that  
25 underlies it, the lower volcanic confining unit, and right

1 away, we see then if this is 750, 740, 760, whatever, there's  
2 upward flow from the carbonate aquifer. It shouldn't come as  
3 any surprise to anybody. That one measurement proves it  
4 beyond a shadow of a doubt. If that number is right, there's  
5 a lot of upper welling from the carbonate aquifer. So that  
6 definitely is part of the truth of the system here.

7           So in terms of the flow path off the site, we then  
8 go to the models I guess to try and integrate all our  
9 knowledge of this whole thing. We carry out this flow tube  
10 analysis, first of all saying, well, I think the steady state  
11 approach makes reasonable sense at this site. There's no  
12 evidence of any major transient sort of occurring as we  
13 speak. There's certainly some thoughts about climatic  
14 transients over a long term time frame, and we'll talk about  
15 that in a minute. We have the upward flow from the carbonate  
16 aquifers.

17           In any case, what the model shows is some kind of a  
18 regional flow tube that goes off to the southeast from the  
19 site in the volcanics, kind of turns the corner, may thin up  
20 a little bit, may spread out a little bit, may thin up again,  
21 but like most plumes that all of us hydrogeologists work with  
22 out in the Superfund Program, solvent plumes and plumes that  
23 we see at other sites in the world, we anticipate this one to  
24 be a long skinny snake. We don't think of it as something  
25 that's going to spread out wildly. Lateral dispersion, so-

1 called, is likely to be small.

2           In my opinion, dispersion is simply a fudge factor  
3 for all the things that might possibly make a flow tube  
4 spread out. It's not a scientific construct of any great  
5 sophistication. This is from the work done by Schwartz and  
6 Sudicky for EPRI actually, but I'm sure that the USGS models  
7 would show similar things.

8           Here was one that was done for the Nuclear  
9 Regulatory Commission. It shows spreading out and then a  
10 focusing of flow lines here. So the whole idea of whether  
11 the flow lines are going to definitely get wider and wider  
12 apart, myself, I feel they could get wider apart in some  
13 places and come back together in other places, in other  
14 words, focusing and de-focusing, both are possible.

15           The general feeling is that hydraulically, we would  
16 anticipate the flow tubes that come out of Yucca Mountain to  
17 more or less keep their flow tube pretty much the way it is.

18           Now, the one thing that could cause them to spread  
19 around in my mind would be long-term transients due to  
20 climatic changes. If the climate is changes in such a way  
21 that the water table distribution under Yucca Mountain is  
22 changing in its shape, then obviously the flow tubes are  
23 going to be changing with time over this very long time  
24 frame. Now, maybe that's what accounts for the geochemical  
25 measurements that seem to indicate mixing down in the

1 Amargosa Desert, because otherwise, there's a bit of a  
2 disconnect there between the hydraulics experts where I kind  
3 of number myself, and the geochemical experts who see mixing  
4 as somehow--you know, they see the geochemical signatures  
5 suggesting quite a bit of mixing. And we in hydraulics don't  
6 really have an explanation for that, and we don't observe it  
7 in the short time frame plumes that we work with in the  
8 Superfund Program.

9           There is some agreement between the geochemists and  
10 the hydraulics people. This is the age dates. This is taken  
11 out of our elicitation and prepared by Don Langmuir. And if  
12 we start to look at the ages and the advective flow rates and  
13 so on that we might expect, it seems like the geochemists are  
14 telling us that the water is, you know, thousands of years  
15 old, thousands of meters away from the site, which would  
16 suggest advective flow rates of a meter a year, or something  
17 like that. And those are the kinds of numbers that we come  
18 up with hydraulically as well. So I think there's some gross  
19 type of agreement there.

20           I'll let you have a look at this slide. I won't go  
21 through it. But the gist of it is that in my opinion, the  
22 rates of flow of unretarded contaminants are likely to be on  
23 the order of a few meters per year overall. Keep in mind I  
24 picture them going faster and slower and faster and slower as  
25 they go through these various, you know, each flow tube

1 hitting the various fault zones and Bullfrog and into the  
2 alluvium and getting hooked around in the alluvium, and so  
3 on. I was one of the ones that estimated I think between 0.3  
4 and 30 meters per year for the unretarded advective flow.

5           Now, I'm not going to speak much about retardation  
6 today, because it's not my area of expertise particularly. I  
7 don't know whether Lynn is going to say much about that or  
8 not. Maybe I'll say just a bit more than I was going to.

9           I guess it's my opinion that the retardation is  
10 likely to be quite important. I mean, radionuclides are not  
11 mobile elements in general. They generally sorb quite a bit.  
12 There's generally a fair bit of matrix diffusion. We heard  
13 this morning of some of the geochemical controls that might  
14 enhance some of those retardations. But I guess, again, just  
15 an overall gut feeling is that these contaminants will be  
16 retarded significantly, maybe by a factor of ten or more, I  
17 don't know. That would probably take them out past the  
18 10,000 years, if they're not out there even before that.

19           There have been other advective flux estimates by  
20 other people and they're kind of all in the same ballpark, so  
21 I guess I think we're sort of starting to zero in on that  
22 number as being something we could live with. Here's what  
23 the panel came up with. That's the one that you already  
24 showed, Kevin.

25           So coming back to the dilution then, to kind of

1 summarize it, if I define it as the contaminant concentration  
2 at the release point, divided by the highest concentration  
3 that's obtained at some potential receptor location, if I  
4 assume the sources are sort of, you know, quite large, that  
5 we have a steady non-decaying source, the receptor is about  
6 25 kilometers away, and we think about concentrations  
7 measures thousands of years after the release, then the  
8 mechanisms that are going to potentially control that  
9 dilution or lack thereof are the focusing of the flow tubes,  
10 which will make the concentrations higher, the de-focusing  
11 and splaying out of them, which will make them lower, the  
12 possible transient flow tube wandering under climatic  
13 changes, which I think is certainly possible, longitudinal  
14 dispersion which seems to be--there is some kind of  
15 longitudinal things going on, perhaps matrix diffusion and  
16 other things going on, the fudge factor, not much lateral  
17 dispersion, in my opinion, not much mixing of the type that  
18 seems to be underlying some of the geochemical models, I  
19 don't see the waters coming in and somehow glomming together  
20 and mixing.

21           We hydraulic people, we think the flow tubes come  
22 along, if one comes from above, it will push the one below it  
23 down a little farther, and off they go. Pumping well capture  
24 could create quite a bit of mixing. Each pumping well  
25 creates a capture zone and sort of brings water into itself

1 and mixes it in the well. I can't imagine you get any credit  
2 for that, but that will happen, you know, and it could  
3 complicate the flow systems down in that area.

4           The panel, I don't think Kevin did show this one.  
5 This was what the panel came up with for dilution factors.  
6 We hedged a lot because we don't know too much about this,  
7 and some people I think, including myself, even had an upper  
8 bound way up as high as like 100 full dilution. But do  
9 notice that almost all the most likely values are, you know,  
10 sort of less than ten, and one is certainly in the ballpark.  
11 There might not be much dilution at all.

12           I guess I'm just about out of time. I've got just  
13 a couple more here.

14           Changed conditions with respect to climate, I think  
15 maybe I'll just let people read these. My feeling was that  
16 the program has a good handle on the climate changes, at  
17 least as good as could be expected.

18           The impact of repository heating, I'm probably  
19 influenced by having been a former member of the thermal  
20 hydrologic peer review team. I learned a lot that few  
21 months, and I became concerned that no all the implications  
22 of the thermal hydrologic saturated and unsaturated system  
23 was understood to the degree that it made me feel  
24 comfortable, and I felt there was still some possibilities  
25 that these temperate effects could extend in the saturated

1 zone in the formation of convection cells or changes in  
2 properties.

3           Bruce Robinson this morning said that their initial  
4 conclusions are that it's not likely to impact the saturated  
5 zone unless there are changes in properties. So maybe we're  
6 reducing one of the uncertainties there.

7           And that leads to a summary of conclusions, which I  
8 think I've pretty much said. I guess in a nutshell, I think  
9 faults are very important. They're not fully understood yet.  
10 I think more work needs to be done to make sure we  
11 understand them. From what I learned yesterday, it seems  
12 like a lot of that work is ongoing.

13           The large hydraulic gradient in my opinion is not  
14 hugely important. I certainly wouldn't be adverse to  
15 spending some more money on it just to get the credibility of  
16 saying we can understand it. But I don't think it's  
17 something that will affect performance assessment, and I  
18 don't think the dilution is likely to be very large.

19           The implications for the Yucca Mountain program  
20 then, for the field program and the computer modeling, I  
21 think follow from what I've been saying. And I'll just leave  
22 it at that and let you have a look at those.

23           And I don't think I'll comment on the elicitation  
24 process. I think Lynn is going to say something about that,  
25 and I can jump in if I want to in his discussion.

1 Thank you.

2 PARIZEK: Thank you, Allan. Questions from the Board?  
3 Debra Knopman?

4 KNOPMAN: Knopman, Board.

5 Allan, in your first conclusion, you basically say  
6 that the Yucca Mountain flow system is not outside the bounds  
7 of hydrologic analysis as it's currently practiced. It is a  
8 tough site, but there are others that are as difficult. But  
9 can you give some summary view, your view, of what the  
10 bottom--what constitutes irreducible uncertainty in this  
11 saturated zone flow system? That is, how low can we go and  
12 how far can we go in reducing uncertainty beyond which really  
13 no one, you know, there's no site that--

14 FREEZE: I don't know if I have the right answer for  
15 you. I believe there's always a level of irreducible  
16 uncertainty at all sites. You go through kind of an  
17 iterative site characterization program, and I think that's  
18 being done here to some degree, and more so in recent years  
19 than in earlier years where you measure things in the field,  
20 you model them, you accept that every time you model them is  
21 not the absolute final answer, but it's the best you can do  
22 now. You carry out some kind of a design for your  
23 repository, you look to see what the implications of that are  
24 in performance assessment, you try to decide whether  
25 additional data would have any worth, you know, you carry out

1 some kind of a data worth system as to whether it's worth  
2 doing more modeling or getting more data.

3           And I don't know that you ever reach an irreducible  
4 level. I guess I think that's a political concept. I think  
5 the--or techno-political, or whatever you want to call it,  
6 that at most sites, the decision to not take any more data  
7 and to actually make the decision to go ahead and build the  
8 damn thing, or whatever, happens in the public domain by  
9 groups like this. You know, it doesn't happen, you don't  
10 ever say, well, we're going to be satisfied with a delta phi  
11 of 2 per cent, or something like that, you know.

12       KNOPMAN: Okay. I guess that's what I was trying to get  
13 you to say, was that you would really not be able to get much  
14 beyond some estimates that were bound maybe within two orders  
15 of magnitude.

16       FREEZE: Well, I don't think I'd be willing to put  
17 numbers on it. I mean, you're coming at this thing from both  
18 sides, and the program at one time or another has flip-  
19 flopped in the way it comes. On one side, you come up from  
20 the bottom trying to understand all the processes, and you're  
21 nervous if there's processes you don't understand. We're  
22 nervous if there's processes we don't understand as the  
23 technical people. And that might be matrix fracture  
24 interactions in the unsaturated zone. I think we all have a  
25 bit of a feeling that we maybe don't quite fully understand

1 that as well as we should, you know. Maybe matrix diffusion  
2 in the saturated zone; is that important or not. So there's  
3 that way.

4           But then coming down the other way, there's the  
5 performance assessment approach where they're doing these  
6 things and they're saying well, it's not sensitive to this,  
7 so why should we waste our time, you know, this is not a  
8 scientific project, it's an engineering project. We're  
9 trying to put a repository in the ground.

10           So somewhere they meet in the middle at I think at  
11 a political level, where both sides aren't hollering too  
12 loud, you know, something along those lines.

13           PARIZEK: Paul Craig?

14           CRAIG: Craig, Board. I have two questions.

15           Linda Lehman mentioned temperature, and I'd like  
16 you to offer an opinion. It hasn't appeared anyplace else in  
17 the conversations I've heard. What significance should we  
18 attach to that, is the first question?

19           And the second question has to do with focusing  
20 effects or jetting effects. Of course an average is  
21 wonderful, but what will really hurt you is if there is an  
22 argument that there is some significant amount of material  
23 that gets focused on just to the place where someone wants to  
24 put in a well. Now, I think you used the language highly  
25 unlikely when you were talking about this kind of thing. I

1 may have misunderstood. But in any event, what I'd like you  
2 to do is to address the technical issue as to how you go  
3 about constraining that kind of a phenomenon. What kind of  
4 data can you collect? What kind of models can you use that  
5 will help you understand and put limits on it?

6       FREEZE: Okay, to the temperature question first, I  
7 guess my feeling, and I think all of us would share this on  
8 the panel, that any data that's available that's pertinent to  
9 understanding the processes and ultimately the directions of  
10 flow is valuable, and the temperature information is one of  
11 those sets of data, and I think you're right, it probably  
12 hasn't been fully integrated into the whole hydraulic scheme.  
13 But there certainly have been attempts to do that.

14               We had some very interesting presentations by Bill  
15 Dudley and Dr. Sass and John Bredehoeft has worked with some  
16 of that stuff. And, you know, we've read all this, and my  
17 feeling is it's helpful and useful in helping us understand  
18 the nature of the flow systems. If we can show that there's  
19 heat plumes, they're in a sense a tracer, you know, and that  
20 would tell us a fair bit. And I think they should be, and  
21 probably will be used by the modelers in calibrating their  
22 model.

23               The focusing of flow, what you're asking, if I  
24 understand it correctly, is how do you avoid, I don't know,  
25 spending too much time worrying about the absolute worst case

1 where somebody suggests a fracture that goes all the way to  
2 the well, you know, with a two year travel time, or  
3 something.

4       CRAIG: Yeah, how do we decide whether this is something  
5 we should worry about or not worry about in a situation where  
6 the mean times with retardation included may be sufficiently  
7 low effect or--

8       FREEZE: Well, I guess that's the first step. The first  
9 step would be that if even that worst case doesn't lead to  
10 anything dangerous, then maybe you don't have to worry quite  
11 so much about it.

12       CRAIG: Well, the worst case, it seems to me, though, we  
13 heard this morning and you seem to be confirming it, leads to  
14 a pretty good situation.

15       FREEZE: Well, first of all, don't quote me on that. I  
16 have never looked at the millirems per year, you know,  
17 calculations in enough detail for me to comment whether those  
18 are safe or not, and I'm also not a toxicological expert.

19       CRAIG: Well, let me--

20       FREEZE: So back off from that one.

21       CRAIG: Let me stipulate that these fast paths lead to  
22 long enough time lags and with retardation, it could be a  
23 significant element. So then we say if that's true, then  
24 what are the real flaws that you have to worry about? And it  
25 seems to me that the one flat which you've absolutely got to

1 deal with is the possibility of some kind of a focusing  
2 effect that produces a highly vulnerable outlayer. If you  
3 can't limit that reasonably well, then you're in trouble with  
4 this.

5       FREEZE: I suppose one way to do it would be to try and  
6 look probabilistically at, you know, what you're saying is  
7 there would have to be a link-up of a bunch of highly  
8 permeable sets of conditions, you know, the high  
9 permeability--the release would have to come in the high  
10 permeability fault. It would have to head right towards a  
11 very high K flow path in the alluvium or something like that.  
12 I suppose one could look at that. There are geostatistical  
13 techniques, you know, to look at the natural occurrences of  
14 these things, and the probabilities of all that sort of  
15 thing, or you'd be multiplying probabilities, and perhaps  
16 you'd be able to show that the probability is very, very low.  
17 But I don't know, you would never be able to show its zero,  
18 I suppose.

19       CRAIG: It won't be zero.

20       FREEZE: Yeah. I don't have a direct answer, but I  
21 would think there ought to be some methods, when we know the  
22 offsets on these faults and we know how continuous these  
23 aquifers are and how likely it is that they get bumped up  
24 against something of high K or something of low K and how  
25 long they are, you know, I would think there should be

1 something. And I presume the models would have a significant  
2 role to play in producing that kind of thing for you.

3 CRAIG: Well, if somebody around the room has an  
4 approach on this one, please come and talk.

5 CHRISTENSEN: Christensen, Board.

6 It strikes me that that's the historic trade-off  
7 and risk between concentrated risk and the probability of  
8 hitting the hot spot, that is, the more focused it gets, the  
9 probability of actually hitting it goes down, but the  
10 consequences when you do are much greater. And I think that  
11 the ultimate importance of that probably comes down to having  
12 greater guidance in terms of what the actual standards are  
13 going to be, how we deal with those standards.

14 CRAIG: Yeah, but through the statistics, too, we have  
15 estimates for where the faults are of some sort. So it seems  
16 amenable to the statistics.

17 FREEZE: It seems to be there's a bit of a catch in that  
18 one, though, and that is that if Amargosa Valley turns into  
19 Las Vegas, which none of us would have predicted 100 years  
20 ago, and there's heavy utilization of the water from the  
21 alluvion aquifers in the valley, that will create capture  
22 zones that will suck this water. I don't think it will  
23 change the travel times a whole lot, but it will change the  
24 receptor locations. It will mean that the chances of a well  
25 going into a hot spot, if such a hot spot were to be there,

1 would be almost one, probably.

2       CHRISTENSEN: Since you raised that question, let me ask  
3 a question that I've been wondering about in this process  
4 that doesn't get mentioned, and it may simply be a different  
5 way of restating the climate change scenario, and that is  
6 imagining down slope from the area, which is a fairly likely  
7 scenario in any population growth situation, and whether that  
8 is equivalent to a climate change that would increase the  
9 slope of the gradient.

10       FREEZE: Yes, I believe it is. In fact, it might even  
11 be more effective in providing the mixing mechanism that I  
12 guess we would all like. But as I say, it's kind of twinned.  
13 It mixes it, but then it sucks it in. It doesn't mix it and  
14 let it get away.

15       PARIZEK: Chairman Cohon?

16       COHON: Cohon, Board.

17       Allan, I'd like to ask you a question or two about  
18 this picture with the three conceptual models of the large  
19 hydraulic gradient. Let's stipulate that a large hydraulic  
20 gradient doesn't matter.

21       FREEZE: Okay.

22       COHON: I mean, I'll stipulate in the sense that we'll  
23 accept your feeling that it doesn't.

24       FREEZE: I was going to say, yeah.

25       COHON: Well, I'll keep talking while you're looking.

1 FREEZE: You keep talking and I'll try and listen while  
2 I find that.

3 COHON: The top one, the top model is the near vertical  
4 low K structural feature, and that's basically the way it's  
5 currently represented in the models that--

6 FREEZE: Well, I think it's been introduced by some of  
7 the modelers almost against their own will.

8 COHON: I understand. I'm not saying they have adopted  
9 that model.

10 FREEZE: Okay.

11 COHON: That conceptual model. But to make the model  
12 work, so to speak, that's what they've done.

13 FREEZE: Okay.

14 COHON: I mean, that's a fair characterization of what's  
15 in the model.

16 FREEZE: I wouldn't--is that true? I think so. Bruce?

17 COHON: Okay. Now, suppose, however, that the one you  
18 favor is in fact correct, that is, the middle one?

19 FREEZE: Well, it's a very simplified picture of a  
20 complicated--go ahead.

21 COHON: No, I understand that. And the question is  
22 we're trying to get the benefit of your insight into what  
23 implications having the top representation might have for the  
24 model, when in fact reality is the middle one.

25 FREEZE: That's a good question. Probably the

1 calibrated model would look pretty much the same, perhaps.

2 COHON: Okay, good.

3 FREEZE: Because there's very few layers in the model.

4 If there were more layers, if we had this represented by

5 eight or ten layers and there was a layer in the middle and

6 it was there with three layers and we did it backwards, you

7 know, but I'd just like to say that the question about

8 whether--I said I didn't think this mattered a whole lot.

9 But the point was made this morning that if these gradients

10 are different up here than these ones down here, then it's

11 going to be a different flux down here and this could lead to

12 be important. That's the counter-argument, and maybe John is

13 going to make it right now, I don't know.

14 CZARNECKI: This is John Czarnecki from the USGS.

15 The model that I presented this morning started out

16 as the middle diagram, which we could not represent without

17 introducing yet another feature, such as the vertical barrier

18 on the top.

19 I should also point out that the bottom model was

20 also part of the current model, in that we've got the

21 carbonate as a very high permeability zone, and just using

22 those units alone was insufficient.

23 I would add a fourth model, and it would take the

24 shape of the water table that he has on the bottom, only

25 along the curved portion, you would have a lower permeability

1 zone extending up gradient as a result of thermal alteration.  
2 And that's a model that we call a spillway model, if you can  
3 use that term. And then I think it makes some sense based on  
4 the thermal regime.

5       FREEZE: There is an overhead in the--that I didn't put  
6 up I think this morning that sort of summarizes Bill Dudley's  
7 many, many suggestions and tries to group them in these three  
8 groups, and he judges them from a much better position than I  
9 can, much more expertise, as viable or unlikely or, you know,  
10 uses words like that for them.

11               I mean, I don't disagree with John. John and I  
12 talked about this lots of times and, you know, as I said,  
13 when we were asked in the elicitation to put some numbers on  
14 this, I said 70-30, or something like that. We don't know.

15               But the point I guess I did want to make is that I  
16 don't think the absolute, you know, this goes back to this  
17 irreducible uncertainty, I think we should understand before  
18 this goes to licensing, I think DOE would be well advised to  
19 have some understanding that's better than the current  
20 understanding of this feature, just from a credibility point  
21 of view, and from a science point of view. But my personal  
22 feeling is it won't impact the TSPA particularly.

23       COHON: The other question I'd like to ask you is about  
24 this combined probability distribution. You put it up, and  
25 it's the same one that Kevin put up.

1 FREEZE: I just took it from Kevin's report. I didn't  
2 have anything to do with producing those.

3 COHON: No, I know. But I'm just trying to identify it  
4 by saying you put it up as well as Kevin.

5 FREEZE: Yes.

6 COHON: It's for Q, the volcanic Q, and your individual  
7 probability distribution is very different from the others.

8 FREEZE: I noticed that.

9 COHON: And from the combined. So that's why I wanted  
10 to ask you in particular. And this is a rough estimate from  
11 eyeballing it, but it looks like the expected value of the  
12 combined distribution is a value that you wouldn't even find  
13 credible. That is, it seems to be almost off your  
14 distribution, that is, the expected value of the combined  
15 looks like about .5, and the upper bound of your distribution  
16 is about .1. So the question is how do you feel about that?

17 FREEZE: To be quite frank, I didn't give it any thought  
18 particularly. I anticipated that we understood how the  
19 system was going to work. We were all going to give our  
20 opinions. I honestly expected there to be much wider  
21 divergence of opinions than turned out on all those diagrams.  
22 And, in fact, the fact that there isn't worries me more than  
23 the question you've just asked me, because it makes me worry,  
24 we were warned that we might be, like all experts, in love  
25 with ourselves and think that we knew more than we did and

1 that our distributions would all be too tight.

2           My own fear was the opposite. My fear was that we  
3 were all going to try and cover our ass to such a degree that  
4 we'd never be embarrassed by these things in the future, that  
5 we tail them way off out to the ends. And so I purposely  
6 tried to kind of not tail mine quite so much as I might  
7 otherwise do. And that's maybe why mine tend to be a little  
8 tighter than some of the other guys perhaps.

9           COHON: So you feel that for something like Q, this  
10 particular parameter, that this kind of--

11          FREEZE: Yeah, they seem pretty reasonable to me. I  
12 mean, I'm obviously a little lower. Kevin kept trying to get  
13 us to let the other people inform us. So I maybe should have  
14 moved mine over a little bit, having learned that four people  
15 whose opinions I respect differed by an order of magnitude  
16 from me, I should have moved over a quarter of an order of  
17 magnitude because I'm a good Bayesian; right?

18          PARIZEK: Other questions from the Board? Staff?  
19 Questions from the Staff?

20                   (No response.)

21          PARIZEK: If not, I thank you very much, Allan. I guess  
22 probably the jury is still out as to whether it's first of  
23 all good wine or a bad wine. We have good wine and bad wine  
24 opinions according to how it drives the program, but thanks  
25 very much.

1           Our next expert is Lynn Gelhar from the  
2 Massachusetts Institute of Technology, who spent time in New  
3 Mexico and New Mexico Tech, and also previously before that  
4 at MIT, and was one of the five experts and he will give us  
5 another look at the review process that he was subjected to.

6           GELHAR: Thank you. It's good to be here today, and I'm  
7 going to provide a sort of contrast with the discussion that  
8 Al Freeze gave us, in that I'm not going to get into a lot of  
9 technical detail. I will look at a few technical points  
10 toward the end of my discussion, but I'm going to focus a  
11 little bit more on what I call possible weaknesses or  
12 limitations of this kind of process, and maybe some  
13 suggestions about how things might be improved to get a  
14 better overall product out of this kind of exercise.

15           So the topics that I will be discussing are some  
16 concerns about the elicitation process itself, first of all,  
17 and then just a summary of some of the key technical issues,  
18 especially ones that I focused on in the elicitation process,  
19 because each of the experts sort of concentrated and made  
20 presentations on selected portions of the information, and  
21 I'm going to give you a summary of some of that. But I  
22 believe the Board will have available the full report of the  
23 group, and there are 25 or 30 pages just presenting my  
24 summary. I'm not going to try to cover all the technical  
25 points in that summary. But then I will finish up with a few

1 suggestions about reducing uncertainties.

2           So let me say a little bit about the process first  
3 of all, and the framework that's involved here is the use of  
4 probabilities. And of course we all know that there are  
5 different perceptions about what probabilities actually are,  
6 or there is a kind of subjective probability which is more  
7 the concept that I believe is being used in this elicitation  
8 process, probabilities as reflecting degree of belief. This  
9 is the Bayesian concept of probability.

10           And a second more classical kind of view of  
11 probability, which views this as a quantitative  
12 representation of repeated experiments, or kind of inference  
13 based on repeated observations, and that's the classical kind  
14 of frequency view of what's involved.

15           The overall process that evolved here I think is a  
16 kind of mixture of these two. But I tend to be in the  
17 classical camp, if you'd like. In other words, I'm  
18 interested in there being a base of information of data that  
19 we can sample in a repeated sense to try to get some  
20 information about statistics. I recognize that in some  
21 cases, degree of belief has a place, but I tend to, if I had  
22 to pick a camp, I'd be in the frequentist camp.

23           And of course the kind of concern that many have  
24 expressed already is one that I also am concerned about, that  
25 this kind of degree of belief, subjective probability, should

1 not become a substitute for actual collection of data and  
2 being able to look at repeated experiments. They might not  
3 be experiments directly at the site. It might be using  
4 closely related information that we can apply to this kind of  
5 situation.

6           Now, another concern that I had was the  
7 relationship of the elicitation process to performance  
8 assessment. I felt that since the product that we're  
9 producing, these probability distributions are primarily to  
10 be used in performance assessment, that I would have been  
11 more comfortable with a process that more directly told us  
12 about how the performance assessment was being done and how  
13 this material really fed into that process. I mean, for  
14 example, one concern that I have is something I call here  
15 probabilistic dilution. I've made a little picture to give  
16 you the sort of idea that I'm thinking about here. And I  
17 believe some of these ideas were coming up in some of the  
18 earlier questions.

19           But let's talk about effective porosity, because  
20 effective porosity is one of those parameters that many feel  
21 is important as it has to do with how long it may take for a  
22 contaminant to move through this aquifer system. And what  
23 I'm using here is--or what I'm looking at is the probability  
24 density function for a kind of effective porosity, or might  
25 be a fracture porosity, plotted on a log scale. And just as

1 a hypothetical, I've said we have five experts, and we don't  
2 have very much information, so the experts can just, well,  
3 make sort of a wild guess or depending on their bias or  
4 experience, come up with, in this case, I would say they're  
5 non-overlapping, and the averaging process is just dividing  
6 each of these by five and putting them together on one graph,  
7 and I have a probability distribution. It's kind of a log  
8 uniform probability distribution for effective porosity.

9           And, in fact, these aren't--the values that come  
10 here are not out of the realm of realities that have been  
11 discussed or have been possibly used, because what we heard  
12 this morning is from the C-wells tracer tests, we're seeing  
13 values that apparently are up in the range of ten to the  
14 minus one, maybe even larger than that, experience with  
15 fracture porosities. In some volcanic materials, the Basalt  
16 flow tops at Hanford have produced ten to the minus fifth for  
17 effective porosities.

18           The value that was used in the LBL simulations, I'm  
19 not sure where they came up with this, but this S-4 kind of  
20 model used a value of ten to the minus four. So there is a  
21 potentially wide range just from overall experience of what  
22 effective porosities might be.

23           And suppose that we had a true distribution. If we  
24 did a large number of tests out at the site in the volcanic  
25 system, we would come up with a distribution that looks

1 something like this.

2           The question I would have then is having this wide  
3 distribution of possible values, is this representing in a  
4 meaningful way the influence of uncertainty? Or does it  
5 under estimate the possibly important influence of a narrower  
6 distribution that has a much more severe consequence, and how  
7 is this kind of difference really accounted for in the  
8 process that one goes through in this situation?

9           So to me, it's sort of a question in my mind. I'm  
10 a little bit uneasy about just spreading out over a wide  
11 range of possibilities and what in effect dilutes what might  
12 be an adverse consequence.

13           And along the same lines, I think--I mean, this is  
14 another reasons why I'm more interested in the link to  
15 performance assessment. Because performance assessment is  
16 just a kind of transformation of these probability  
17 distributions into another space. It's a non-linear  
18 transformation, and because it's non-linear, just because  
19 this distribution looks like this, the distribution that  
20 comes out for, say, concentration at a downstream point of  
21 impact is not necessarily going to look at all like the  
22 distribution you started with. And parts of this  
23 distribution may be much more important than other parts of  
24 the distributions in the case of a non-linear transformation,  
25 which is what PA is.

1           So that's supposed to be a little explanation of  
2 what I mean by probabilistic dilution. Is there something  
3 like that going on in this kind of process?

4           So I felt that the performance assessment, or our  
5 process of elicitation would have been more enhanced if we  
6 had a more direct focus on performance assessment, including  
7 maybe some sensitivity kind of information on overall  
8 performance assessment, or just the notion of a more direct  
9 link between performance assessment and site characterization  
10 so that we can be using performance assessment as a way to  
11 set priorities about site characterization, and also have a  
12 more clearly documented connection between the parameters and  
13 conceptualizations that are needed in performance assessment,  
14 and the sort of observable characteristics that we have in a  
15 field data collection program.

16           I feel that there's a kind of gap in this overall  
17 process between what kind of data are collected and how this  
18 produces performance assessment parameters that if you're  
19 going to have a more defensible process, you want to be able  
20 to close that kind of gap.

21           So that's the point here regarding the link between  
22 site characterization and performance assessment.

23           Now, I also have some concerns about just the  
24 nature and availability of information, possibly because I've  
25 taken maybe a little bit different perspective about how I

1 looked at the information that is presented, because we were  
2 given an awful lot of information, and I said some of it--  
3 well, I think a fair amount of it was ill-focused, maybe  
4 purposely ill-focused, and we were intended to provide a  
5 focus or clarify things in one way, and maybe there's nothing  
6 wrong with that, but there is also a focus, a framework, that  
7 could have been used more where we could see how the project  
8 researchers see their work giving information about  
9 performance assessment, or parameters needed in performance  
10 assessment. Tell us; here is how you're going to use this to  
11 come up with this parameter that you need in performance  
12 assessment, and here is the uncertainty that you think  
13 applies to this estimate, and use that kind of framework as a  
14 starting point for an assessment of the type that we've  
15 developed.

16           One of the reasons that I found this to be an  
17 attractive kind of thing is that I went through with a  
18 similar kind of process in terms of the modeling and  
19 performance assessment, risk assessment on the Nevada Test  
20 Site about a year before this process, and that was entirely  
21 built around performance assessment, all the way from the  
22 site characterization data to the results of the performance  
23 assessment were the focus of that kind of process. So  
24 looking at the whole picture. And I found that to be a good  
25 way to focus in on the things that are important.

1           Now, I also have, just from long experience with  
2 oral presentations and transparency copies and things like  
3 this, found that it's difficult to sort out reliable  
4 information from presentations of that type. It's very  
5 important to have reviewable material, as far as I'm  
6 concerned, and I think we all appreciate that. To what  
7 extent we put that as a constraint on how we look at this  
8 information may vary. I put that as a fairly severe  
9 constraint. So if I didn't have written information that I  
10 could review, if all I had was some transparencies or  
11 presentation, I did not place as much weight on that kind of  
12 information. I just--I'm not as comfortable not being able  
13 to see the pertinent details about how these things develop.

14           There is also a question of timeliness and  
15 organization of an effort like this, because in several  
16 cases, I did not feel that the information got to the panel  
17 in a timely fashion. They're too late in the process to  
18 really, in a comfortable way, be able to assimilate the  
19 information in a way that the panel could interact about the  
20 nature of the information. I mean, the C-Well test is one  
21 thing I've complained about before, and complain about again,  
22 because we got the C-Well tracer tests and hydraulic result  
23 just a few days before we had to put together our kind of  
24 group, preliminary group assessment.

25           So it seems to me if you're going to go through

1 what is a fairly time consuming and costly process, there  
2 should be the courtesy and the like of providing information  
3 before you have workshop meetings, say a couple weeks before  
4 workshop meetings. We know what the agenda is and we get the  
5 information before it's presented so one can effectively  
6 discuss and question and the like. And I don't see any  
7 reason why those kinds of things could not have been done in  
8 this kind of setting.

9           So those are sort of the complaints for Kevin and  
10 others which are probably--there are probably many good  
11 reasons, scheduling and the like that produced this kind of  
12 situation.

13           Then I wanted to talk in a summary sense about a  
14 few of the technical issues that are involved, and maybe give  
15 some contrasting perspectives with Al Freeze' comments. And  
16 what I will do is just give these summary notions about a few  
17 of the components of the overall project, starting with the  
18 regional flow model, which we heard some update on this  
19 morning. And the regional flow model I am skeptical about  
20 even if you do the best that you can to reduce uncertainties  
21 in the regional flow model, that it can be expected to  
22 provide you tight information about what's going on at the  
23 site.

24           There's so many unknowns in the regional flow  
25 model, the amount of recharge, the spatial distribution of

1 permeabilities, that it's so far from being able to specify  
2 very much detail from a model like that. Its role is for a  
3 bigger picture kind of thing, and its role is to address  
4 things like the rough idea of what climate change effects  
5 could be, and can we represent those in a reasonable way.  
6 Linking it directly to a smaller scale model, I think is not  
7 as likely to be feasible as what I'm talking about here in  
8 the site scale model where the--my concerns in the site scale  
9 model are getting more faithfully into the site scale model  
10 and representation of the major geologic features. And I  
11 believe that is moving in that direction, but with the  
12 discretization, a kilometer and a half discretization that  
13 has been used I think there are lots of questions about  
14 whether you're really getting the important geology into the  
15 system.

16           I would also be concerned just about the geologic  
17 information, how far down gradient do we go before we  
18 actually get into the alluvium, and do we know decently where  
19 the water table goes from the volcanics into the alluvium,  
20 and I haven't seen a clear demonstration that that's very  
21 well known.

22           So I would not see it as a very likely prospect of  
23 really being able to reduce uncertainty about local site  
24 conditions by linking to the regional model. The way I would  
25 look at it, rather, is that we use things like the aquifer

1 tests, which fortunately are stressing and influencing quite  
2 a large area, out to several kilometers, as the way to impose  
3 a flux on this model in the areas that we're really concerned  
4 about, the areas down gradient from the site, to understand  
5 the nature of the flow and the properties in those regions.

6           So that's the point here. You should use flux  
7 imposed by the long-term aquifer testing in the calibration  
8 of that model.

9           The advective flux vector, that's the  $Q$  that we're  
10 looking at the probability distributions of, and I believe  
11 the reason that--or I think those probability distributions  
12 are actually quite tight. I mean, Al is almost in agreement  
13 as far as uncertainties in ground-water conditions are  
14 concerned, and I believe the reason that it's tight is that  
15 we have a tight measurement on hydraulic gradient. We know  
16 what the hydraulic gradient is, and we have a decent aquifer  
17 test in the pertinent area just down gradient of the site.

18           So where the information is coming from, there  
19 isn't much to debate. A number of aquifer tests have been  
20 done, and the numbers are in a range that's reproducible. So  
21 this characteristic of a specific discharge of a half a meter  
22 per year I think is quite well established.

23           Now, just to present something that is not well  
24 established, however, is how you convert that into a  
25 velocity, because that goes to these effective porosities and

1 things like that, and I just picked out, I'm not advocating  
2 this number at all, ten to the minus three, but if you divide  
3 that into the Q, you've got extreme rate of movement, and I  
4 don't know how well we can, you know, acknowledging that  
5 there is geochemistry and so forth, I still don't know how  
6 well we can determine what the velocities of the water is in  
7 this. They're kind of an average velocity in this kind of  
8 system.

9           There are a large number of single hole hydraulic  
10 tests, and some of the most important kind of information, as  
11 far as I'm concerned, is that that comes from the old bore  
12 hole flowmeter logging tests. You just put a little  
13 propeller--you pump your well and put a propeller down in  
14 there and you see where you get water coming into the hole as  
15 you extract water from the hole, and Al showed I think one of  
16 these spots, but you will find pictures--well, here's an  
17 example from a--that's Bill Arnold's presentation. The  
18 patched zones here show the zones whereby the flow metering,  
19 the in-flow was predominantly occurring in each of these bore  
20 holes. And in my mind, this brings in what I might want to  
21 see in this kind of thing, is some kind of continuity in  
22 these pictures, and it's unclear whether the attractive idea  
23 that lithology determines the degree of fracturing and the  
24 distribution of permeability in these systems is really a  
25 valid idea.

1           I have not seen the information put together in a  
2 way that demonstrates that each of these in-flow zones that  
3 has been measured here is related in a simple way to  
4 lithology so you can recognize where the permeable zones  
5 would be just by knowing, say, a welded tuft. And that seems  
6 to me to be a very important question.

7           Now, maybe someone knows if it's resolved. But as  
8 far as information that we got, it was not clear. So that's  
9 the basis for my suggestion here that it may not be clear  
10 that the high permeability zones within the strata are easily  
11 related to lithology. And these kinds of questions are  
12 important because ultimately, you're interested in sorptive  
13 characteristics on the pathways where the water is moving,  
14 and if we don't know what those pathways are, and it seems  
15 that the strategy of characterizing sorption is to relate  
16 sorption characteristics to lithology, and if we don't have  
17 this relationship between flow and lithology, then we don't  
18 really have I say a workable strategy of characterizing  
19 sorption characteristics.

20           The single hole hydraulic testing, more traditional  
21 hydraulic testing, provides only relative information. It  
22 seems to run one or two orders of magnitude lower in  
23 hydraulic conductivity than something like the aquifer test  
24 at the C-Wells. Well, it's not clear what's producing this  
25 kind of difference.

1           The aquifer test, the C-Well work is very important  
2 work, as far as I'm concerned. And the fact that we're  
3 seeing responses out to several kilometers from pumping these  
4 wells, where we know the flux and we can see it pretty much  
5 follows an equation, means that we have a fairly transmissive  
6 system here. You know, the transmissivity is in thousands of  
7 meter squared per day, and that is consistent with the low  
8 gradient.

9           The advantage of having this kind of aquifer test  
10 is that we have a known flux so we can eliminate the  
11 question, and this makes less important the question of  
12 what's happening upstream, because we use the measured  
13 conductivity and the measured gradient and we know how much  
14 water is going through that part of the aquifer.

15           Where exactly it comes from, I'm not so sure how  
16 important that is, but we know how much water is moving  
17 through that part of the aquifer, or that's the way I am  
18 interpreting this information.

19           Now, the tracer tests, I think it's still an open  
20 question about what these mean. I would be more comfortable  
21 if we were seeing more dramatic differences. Say with regard  
22 to matrix diffusion, the differences are really quite small,  
23 and I'd want to make sure that we understand what could be  
24 other complications in these tests that might be producing  
25 these differences.

1           The fact that you have two peaks and apparently two  
2 pathways means that the kind of classical interpretation that  
3 has been used is not necessarily an adequate interpretation,  
4 because as soon as you have two different pathways with  
5 different velocities, then there's a question of transverse  
6 diffusion between the different pathways that is not really  
7 represented in these kinds of models.

8           So there are questions like that, and I'm still not  
9 sure what these large effective porosities really mean. I  
10 mean, what you're doing in this tracer test testing first of  
11 all a very small part of the overall system that you're  
12 interested in. The wells are, what you're testing is a  
13 portion of the aquifer between these wells that are 30 or so  
14 meters apart, and it's not clear to me whether some  
15 complications in the flow field, some three dimensionality or  
16 anisotropy or something in which the flow field has a more  
17 complicated pathway than a flow field, which is assumed in  
18 this kind of analysis, is what's producing the larger  
19 effective porosity, or what it is. It's important to  
20 understand what the limitations might be in the  
21 interpretation of this.

22           I mean, it would be a gross speculation to try to  
23 extrapolate from the 30 meter spacing tracer tests to what's  
24 going to happen over many kilometers. So there's an  
25 important difference between the tracer tests. The tracer

1 test samples adjust this interval between the wells. The  
2 aquifer test influences a large area in kilometers and  
3 produces a flow in that area, and produces information on a  
4 scale that's closer to the scale and is more integrated,  
5 because the difficulty of a complex system like this is if  
6 you're going to try to say, as Al is maybe suggesting only  
7 conceptually, that there is a very detailed and complicated  
8 distribution of permeable features in this system, doesn't  
9 seem very likely that you're going to be able to map those  
10 out in complete detail.

11           You might know their geometry, but to map out their  
12 hydraulic properties would be a very challenging kind of  
13 thing to do. What you'd rather be able to do if you can is  
14 make integrating measurements. If you can make integrating  
15 measurements that give you the properties approaching the  
16 scale that you're interested in, I view that that's a more  
17 direct attack on the characterization kind of problem.

18           Well, Victor sort of suggested that I say a little  
19 bit about dispersion, dilution questions, so I thought I'd  
20 add it. There is a single sheet. If you didn't get that,  
21 there's a single sheet in the back that gives this additional  
22 information, and I want to give sort of say the introductory  
23 lecture about dispersion and what dispersion is in a field  
24 setting. And it really builds on the concepts and  
25 descriptions that Al Freeze was providing, because he's

1 suggested that there is a complex distribution of permeable  
2 paths where there are probably variations along the paths,  
3 that there isn't a single continuous path of very high  
4 conductivity that extends for many kilometers. And it's the  
5 interactions at several different scales that produce a kind  
6 of dispersive effect.

7           You can think of first of all the very largest kind  
8 of scale, and what I'm trying to do here is actually draw a  
9 distinction between spreading and mixing and/or dilution.  
10 That's the distinction that we want to be able to recognize.  
11 And you could think of having, say, a plume that's in a  
12 heterogeneous aquifer that's made up of two layers. It might  
13 be an aquitard and an aquifer, and say the conductivity  
14 contrast is just a factor of two, if you have a hydraulic  
15 gradient applied to this system, the part that's in the  
16 aquitard versus the aquifer is going to move twice as fast,  
17 and what you'll end up with is a plume that sort of  
18 bifurcates. You'll end up like a dumbbell type plume, where  
19 the elements of the plume have spread out because there's a  
20 variation in hydraulic conductivity, but you don't find  
21 significant dilution in this kind of situation.

22           That is in contrast to having a large plume in a  
23 medium that has fine scale variation that is small compared  
24 to the size of the plume. In that situation, the plume gets  
25 chopped up in a small sense and spreads out at the same time

1 that the concentrations are decreased. And this kind of  
2 hierarchy of scales of variation in fluid velocity or  
3 hydraulic conductivity are what it takes to produce the kind  
4 of dilution effect. And, in fact, what we know from recent  
5 theoretical developments is the finest scale of variation in  
6 hydraulic conductivity has a very important role in this  
7 process of creating dilution, the reason being that in order  
8 to produce any dilution in any of these kinds of systems, we  
9 ultimately have to get down to molecular diffusion. The only  
10 way we can decrease concentrations is ultimately to have  
11 molecular diffusion act effectively.

12           And if you have lots of very fine scale variation  
13 in the flow field and in hydraulic conductivity, this  
14 produces a situation where you produce all kinds of little  
15 fingers, high velocities, low velocities, high velocities,  
16 and you greatly increase the surface area and the gradients,  
17 concentration gradients over which diffusion can actually  
18 act.

19           So it's this small scale chopping up of plumes that  
20 is needed to produce dilution. Otherwise, there would be no  
21 dilution at all. The plume would just move around and it  
22 wouldn't decrease its concentration. So it's a kind of  
23 hierarchy of variations, but the variations on a scale  
24 smaller than the plume and including those much smaller than  
25 the plume, which we will never be able to characterize

1 completely are what we throw into the sort of dispersion  
2 description that's involved.

3           The dispersion effect we know is related to the  
4 variability of hydraulic conductivity and the scale of  
5 variability of hydraulic conductivity. And that has been  
6 confirmed by independent experiments where we measure this  
7 variation in hydraulic conductivity on an aquifer, like at  
8 the Borden Site in Canada or the Cape Code Site in  
9 Massachusetts, we have measured these kinds of properties and  
10 we know that we can predict this kind of characteristic.

11           So not that such measurements are actually  
12 practical in the Yucca Mountain setting, but what I have done  
13 in my assessment of the dispersion characteristics is really  
14 build on the data from many sites where essentially this  
15 dilution process has been measured by primarily looking at  
16 the behavior of plumes.

17           And what is identified on this graph is many  
18 different observations, field observations, at scales up to  
19 scales of interest, directly of interest in this Yucca  
20 Mountain setting. I put on here the value of longitudinal  
21 dispersivity that's coming out of the C-Wells, and you can  
22 see that that falls within the range that is involved here,  
23 and I've also identified with the open symbols here several  
24 observations in fractured rock settings where dispersion,  
25 longitudinal dispersion coefficients have been identified,

1 and then shown on here the geometric mean, basically the X  
2 and plus or minus two sigma values which were the basis for  
3 the dispersivities that I assigned in this case. So that's  
4 basically how I arrived at dispersivity which ultimately  
5 relates to dilution.

6           Now, the transverse dispersion we know is usually  
7 quite small and it's more influenced by variations, unsteady  
8 flow characteristics, variations in the direction of the  
9 hydraulic gradient, for example. What we know from the  
10 Borden site experience, in contrast with the Cape Code  
11 experiment, is that the Borden experiment has a much larger  
12 fluctuation in the direction of the hydraulic gradient, and  
13 we understand hydrologically why that has to do with the  
14 discharge point of the ground-water changing seasonally.

15           Cape Cod has a smaller degree of variation, and a  
16 question that I looked at a little bit is to what extent on  
17 the Yucca Mountain site do we have, or what one might guess  
18 is that you have a relatively steady system in this arid  
19 setting, and it's borne out. If you look at numbers, the  
20 variation in the direction of the hydraulic gradient is maybe  
21 only two degrees, based on the triangle of wells that we can  
22 pick out at the site, whereas--well, it's not that much  
23 larger on Cape Cod. It's about three degrees for the same  
24 kind of thing.

25           But what we understand is that this influence of

1 plumes sort of wandering around a little bit through a  
2 heterogeneous aquifer is what produces this transverse  
3 dispersion and mixing. And the other graphs here just show a  
4 summary of how I arrived at the ranges for the--this is the  
5 vertical transverse dispersivity, which is the most  
6 controlling value. And you see what we're dealing with in a  
7 geometric mean sense is values less than a centimeter. We're  
8 dealing with very small vertical dispersivity.

9           So overall, I agree that there is not going to be--  
10 or provided that the release is practically steady state,  
11 there is not going to be very much overall dilution, and you  
12 can make calculations of what the dilution would be,  
13 depending on the configuration of your source and the  
14 magnitude of these dispersivities.

15           The horizontal dispersivity again is not very  
16 large, probably quite a bit smaller than values that are  
17 being used or at least that Bruce was showing us this morning  
18 in terms of transverse dispersivities in the current  
19 analysis.

20           Now, another factor that I believe you need to  
21 think about especially if longitudinal dispersivities are  
22 coming into the picture is that they can be different for  
23 differently sorbed species. For heterogeneously sorbed  
24 species, you get a kind of spreading of contaminants that's  
25 due to the fact that the sorption characteristics themselves

1 are heterogeneous, and that should be considered as well.

2           Well, I'd like to just finish up then by going  
3 through the list of points that I had included in my report  
4 about reducing--I guess I would say reducing my uncertainties  
5 about this. It may be that someone else has some additional  
6 information or has a different perspective. This is reducing  
7 my uncertainties, and these are sort of priorities that are  
8 set. A better way to set priorities would be to build on  
9 your PA, on your performance. Since I didn't have that, this  
10 is just sort of my biases about what I think is likely to be  
11 important.

12           So large scale hydraulic and tracer tests, and I  
13 mean large scale relative to what has been done, because what  
14 has been done at the C-Wells is 30 meters apart and I'd like  
15 to see tests getting out to a half a kilometer or a kilometer  
16 if that's feasible. Then we're starting to integrate many of  
17 these complex features, whereas you might be testing just one  
18 special characteristic, a small part of the aquifer with the  
19 small 30 meter or so test. So 500 to 1000 meter well  
20 spacing.

21           Dipole configuration. The dipole configuration has  
22 the advantage over the radial flow configuration that was  
23 used, in that you produce a force flow field and you can  
24 separate dispersion and retardation effects, and matrix  
25 diffusion is just a kind of retardation effect. So you want

1 to be able to try to separate those things out.

2           Different tracers with more contrast and molecular  
3 diffusion coefficient are also desirable kinds of things to  
4 be included in something like that. And we're talking about  
5 a long-term and costly endeavor that should be very carefully  
6 designed, and this is the kind of thing where I think there  
7 should be external review of the plans, not looking after the  
8 fact at what didn't work, but looking at what could make a  
9 difference before this is done.

10           So this would be--this is a first priority as far  
11 as I'm concerned, to try to get at the crucial transport  
12 properties.

13           Now, I think you may be able to get more  
14 information out of the single bore hole tests, some kind of  
15 reevaluation, up to date, maybe three dimensional simulation,  
16 so forth, because they cover such a large part of the site.  
17 There's spatial information in those that might be quite  
18 valuable.

19           The improvements in the site scale model I've sort  
20 of alluded to already, better refinement and using the  
21 aquifer test and calibrations.

22           Another kind of measurement that may be suitable to  
23 try to resolve the matrix diffusion question is looking for  
24 evidence of matrix diffusion or the lack thereof in an  
25 ambient sense. And the reason I bring this up is that

1 apparently this has been done successfully in looking at some  
2 of the perched waters up north of the site, where they have  
3 looked at waters extracted from fractures, and then from the  
4 matrix, and they see a difference, an order of magnitude  
5 higher chlorine concentrations in the matrix than in the  
6 fractures.

7           I don't know whether anything like that has been  
8 done at any saturated zone settings, but in portions of the  
9 rock where we expect significant flow and it's not clear how  
10 much matrix diffusion might be involved, it seems to me this  
11 kind of in situ evaluation of matrix diffusion is something  
12 that should be attempted. So that's the main point here. I  
13 mean, there would be complimentary kind of lab tests, but I  
14 think some of those have been done. But I would focus on  
15 natural fracture surfaces.

16           And then I believe you can improve or maybe build  
17 confidence in the C-Wells information by looking at  
18 alternative interpretations and better documentation of  
19 what's involved. I mentioned one, transverse dispersion  
20 effects. And, finally, I am not comfortable with the  
21 transferability of the lab sorption information into the  
22 field. I don't think the case has been made for that as yet,  
23 and I'd like to see the case made. That's really what it  
24 amounts to.

25           So I think that's what I have to say. Thank you.

1           PARIZEK: Thank you, Lynn. Questions from the Board?  
2 Alberto Sagues?

3           SAGES: Sagues. Very quickly, just to clarify this,  
4 the units of dispersivity are in meters or--

5           GELHAR: Correct.

6           SAGES: Then it's the property of a system and not  
7 property of--not intrinsic property of the medium?

8           GELHAR: Well, we multiply this length by the velocity  
9 to get a diffusion like coefficient. I mean, it's property  
10 of the medium, although it is also influenced by the history  
11 a little bit.

12          SAGES: That's fine.

13          PARIZEK: Other Board questions? Staff?

14                   (No response.)

15          PARIZEK: If not, I think we ought to have our break.  
16 But we're going to again have to cut this break short in  
17 order to allow time for the remaining presenters and still  
18 round up at the end. So how about about eight minutes for  
19 break? And just bring your coffee back to the table. It's  
20 better that than if we truncated the end or stay here till  
21 dark.

22                   (Whereupon, a brief recess was taken.)

23          PARIZEK: We should reassemble. We will see the sun  
24 set, I believe, from this room.

1           Our next presentation will be by Bill Arnold from  
2 Sandia National Labs, and he will look at the saturated zone  
3 flow and transport analysis in total system performance  
4 assessment for Yucca Mountain.

5           ARNOLD: Okay, thank you. What I'd like to accomplish  
6 here is I'd like to give you a little bit of background, some  
7 more detail on implications of some of the issues we've been  
8 talking about today for performance assessment calculations.  
9 I want to give you a very brief summary of how we're  
10 performing these calculations for the saturated zone in the  
11 TSPA, and also try to link some of this information that's  
12 come from the saturated zone expert elicitation to what we're  
13 doing in TSPA.

14           The processes that are important in terms of  
15 performance for TSPA, first of all is ground-water advection  
16 because this is the process which moves contaminants from  
17 beneath the repository in the saturated zone to the  
18 accessible environment. diffusion of dissolved radionuclides  
19 into the rock matrix, because this is really an issue that or  
20 a process that influences how much of this median is  
21 available for storage of a contaminant during transport.  
22 Mechanical dispersion of dissolved radionuclides because this  
23 leads to a reduction in concentration. Geochemical  
24 retardation by sorption on mineral grains, which is a  
25 retardation process which slows the movement of contaminants,

1 and potentially dilution at a pumping well would reduce the  
2 concentration that's actually delivered to the biosphere.

3           And what I show here is a flow diagram of a portion  
4 of the TSPA calculation. All of the upstream components  
5 shown here are feeding into unsaturated zone transport model.  
6 The link between the unsaturated zone transport model and  
7 the saturated zone flow and transport modeling is a  
8 radionuclide mass flux history. So this is the coupling  
9 upstream from the saturated zone.

10           Downstream from the saturated zone component of the  
11 analysis is a radionuclide concentration history, which is  
12 then fed to the biosphere model, which is used to calculate  
13 radiological dose. And this radionuclide concentration  
14 history would be for several radionuclides. Also, I  
15 indicated that climate change history influences other  
16 components of the system such as unsaturated zone transport  
17 and saturated zone transport. What's being done in the TSPA  
18 calculations is we're considering three discrete climate  
19 states; present climate, a long-term average climatic  
20 conditions roughly corresponding to conditions 21,000 years  
21 ago, and some sort of very wet super pluvial condition. And  
22 I'll try to indicate how that influences the saturated zone  
23 modeling.

24           Just a figure to show you the area again that we're  
25 talking about. The outline of the repository is shown in

1 red. General direction of ground-water flow in the saturated  
2 zone is shown by the blue arrows. The 20 kilometer boundary  
3 from the edge of the repository is also indicated here. This  
4 is being taken as a compliance boundary, the primary  
5 compliance boundary for calculation of concentration as  
6 passed to the biosphere model.

7           The way in which these calculations are being  
8 performed, we're using flow and transport modeling at two  
9 separate scales, sub-site scale flow and transport modeling  
10 for transport out to 5 kilometers, and then the site scale  
11 model as described by John Czarnecki earlier today for  
12 transport out to 20 kilometers. The need for two models here  
13 is chiefly driven by lack of geologic and numerical  
14 resolution in the currently available calibrated site scale  
15 model. So a sub-site scale model was used that incorporates  
16 a more detailed geologic framework model immediately down  
17 gradient of the repository, and also utilizes a higher  
18 resolution grid and the hydrostratigraphic definitions for  
19 transport out to 5 kilometers.

20           The two models are coupled at the 5 kilometer fence  
21 through the radionuclide concentration term. So radionuclide  
22 concentration as simulated by the sub-site scale model is  
23 passed to the site scale model at that location.

24           We're using an abstraction method here for the TSPA  
25 realizations. The full Monte Carlo TSPA runs will use the

1 convolution integral method to approximately radionuclide  
2 transport in the saturated zone, and this is a much more  
3 numerically efficient method than running the full three  
4 dimensional flow and transport models for each realization in  
5 the TSPA runs.

6           Just to show you what the simulations look like,  
7 this shows the outline of the sub-site scale model. The blue  
8 crosses here are located 5 kilometers out from the  
9 repository. This is a plot of simulated concentration at the  
10 water table over this area, assuming a unit of mass flux  
11 source at the water table beneath the repository. At the  
12 bottom is a cross-section taken along this 5 kilometer fence  
13 showing the distribution of simulated concentration in the  
14 vertical direction. So this is a steady state, or nearly  
15 steady state plume after some long time period following  
16 initiation of the source beneath the repository. So this is  
17 the sub-site scale modeling.

18           The site scale model picks up transport at the 5  
19 kilometer fence. It's indicated here. And carries it  
20 outward to the 20 kilometer fence, 20 kilometer boundary.  
21 Again, the outline of the repository is shown in red, and  
22 this is--the colors indicate a simulated concentration on the  
23 log scale. You can see that the general direction of flow is  
24 to the south, southeast from this 5 kilometer fence area. At  
25 the bottom here, I also have a cross-section showing

1 simulated concentration along that 20 kilometer boundary.  
2 The highest concentrations are shallow, simulated to be  
3 shallow in the saturated zone. The zero depth here  
4 represents the water table, so this is depth below the water  
5 table.

6           And in the TSPA calculations, we're using a single  
7 concentration at a hypothetical pumping well in the center of  
8 the plume. Here you can see that the plume, the simulated  
9 plume depth is about 500 meters.

10           I mentioned earlier that we're using the  
11 convolution integral method to approximate flow and transport  
12 in the TSPA runs. This is a slide. This flow chart explains  
13 that method. We use an assumed pulse input of radionuclide  
14 mass flux and feed that into the three dimensional saturated  
15 zone flow and transport models, both the sub-site scale  
16 model--well, at the repository footprint in the sub-site  
17 scale model, which is subsequently passed to the site scale  
18 model. At 20 kilometers, we simulate a generic break-through  
19 curve for this assumed unit pulse input, and this process is  
20 carried out numerous times for multiple realizations of the  
21 system, including parameter uncertainty in the transport  
22 model.

23           So we end up with a library of these generic break-  
24 through curves for different radionuclides for different  
25 realizations of the system.

1           Now, within an individual run of the TSPA  
2 calculations, the UZ transport model simulates a radionuclide  
3 mass flux history at the water table. This is combined with  
4 this generic break-through curve, with one of the generic  
5 break-through curves from this library of realizations,  
6 through the convolution method, the radionuclide  
7 concentration history 20 kilometers down stream is calculated  
8 as a function of time.

9           We've broken down the TSPA analyses that we're  
10 going to perform into a set of Base-Case calculations and  
11 sensitivity studies or auxiliary studies that we're going to  
12 perform. In the Base-Case analyses, the focus is on  
13 uncertainty in transport characteristics of the saturated  
14 zone. The transport characteristics being deemed to be first  
15 order in terms of their effect on performance of the  
16 repository, and the first of the important uncertainties that  
17 we're evaluating here is uncertainty in effective porosity.  
18 And we're using the effective porosity conceptual model here.  
19 This is a single continuum representation of the system for  
20 transport.

21           You can think of this effective porosity as  
22 representing that fraction of this medium that is available  
23 for ground-water flow and/or solute storage and sorption.  
24 This is a parameter about which there is a great deal of  
25 uncertainty. It is a lumped parameter which includes really

1 different processes, including matrix diffusion or lack  
2 thereof. If we have complete matrix diffusion, then  
3 basically the entire matrix porosity is available for solute  
4 storage. If not, we have some lower fraction of the medium  
5 available.

6           This parameter also accounts for heterogeneity or  
7 flow channelization of the system. If transport through the  
8 system bypasses large volumes of this medium, then that would  
9 tend to reduce the effective porosity as well. We're using a  
10 broad distribution here encompassing the expert elicitation  
11 estimates.

12           Next parameter is dispersivity, which was discussed  
13 by Dr. Gelhar just before my presentation. We're using  
14 distributions for longitudinal and horizontal transverse  
15 dispersivity taken from the expert elicitation. Low values  
16 of vertical transverse dispersivity that Dr. Gelhar mentioned  
17 will be evaluated in the sensitivity studies. This is  
18 because the numerical models that we have available for use  
19 in TSPA are not adequate for evaluating or simulating  
20 transport under--assuming these very low values of  
21 dispersivity. And I'll discuss that in a minute also.

22           Okay, the process of sorption, we're assuming a  
23 linear sorption model. The distributions of effective  $K_d$   
24 values for all the volcanic units are taken from the work at  
25 Los Alamos. The distributions of effective  $K_d$  values for

1 alluvium and the carbonate units are taken from expert  
2 elicitation, this expert elicitation and from the literature.

3           And, finally, colloid-facilitated transport is  
4 being simulated using an equilibrium model which Bruce  
5 Robinson describe briefly earlier today. This is the  
6 partition coefficient model. This is also a parameter about  
7 which there is a great deal of uncertainty, as well as  
8 conceptual uncertainty about the model itself. And we are  
9 incorporating a relatively broad distribution of this  
10 partition coefficient, this Kc value in simulating colloid-  
11 facilitated plutonium transport.

12           Okay, the sensitivity studies that we have planned,  
13 I should mention that this is very much a work in progress.  
14 The Base-Case calculations are in progress now, fairly well  
15 firmed up. The sensitivity analyses, we're still working on  
16 exactly how we're going to do this, some of this work. But  
17 uncertainty in the permeability distribution and ground-water  
18 flux will be examined in the sensitivity studies. We want to  
19 evaluate the effects of the uncertainty in the distribution  
20 of permeability and in ground-water flux as elicited from the  
21 expert panel. So we want to look at both uncertainty in the  
22 ground-water flux through the system, as well as flow  
23 pathways. Right now, we're using the calibrated sub-site  
24 scale model and calibrated site scale model, so there is no  
25 uncertainty in the flow path in the Base-Case analysis, but

1 this will be assessed in the sensitivity studies.

2           We also want to look at the influence of  
3 heterogeneity and flow channelization through the use of  
4 geostatistical simulation of permeability within the system,  
5 including both intra-unit heterogeneity and the possible  
6 influence of structural zones, faults, so forth, on transport  
7 through the system.

8           And the small values of vertical transverse  
9 dispersivity are going to be evaluated using analytical  
10 solutions. These analytical solutions, however, require an  
11 idealized representation of the system, single velocity,  
12 uniform flow field through homogeneous medium, but there are  
13 both steady state and transient solutions that we can make  
14 use of for this analysis. And we also plan to include an  
15 evaluation of dilution in a pumping well for these analyses.  
16 Very small values of vertical transverse dispersivity would  
17 indicate very thin plume, on the order of meters or tens of  
18 meters, versus the simulations that I showed you before that  
19 indicated a plume on the order of 500 meters thick.

20           So if we have a very--if we're simulating a very  
21 thin plume, it's reasonable to assume that there would be  
22 some dilution, some mixing of that concentration in a pumping  
23 well, and we plan on evaluating that.

24           Some additional considerations relative to the  
25 results of the expert elicitation, we're going to make

1 quantitative comparisons of dilution factors simulated in the  
2 TSPA calculation with the expert elicitation results. You  
3 saw the dilution factors that were presented earlier.

4           And, finally, there were several issues which we  
5 decided to exclude from explicit evaluation in TSPA, in part  
6 on the basis of the expert elicitation results. For example  
7 here, uncertainty in the model of the large hydraulic  
8 gradient; this will not be evaluated explicitly in the TSPA  
9 calculations, or the influence of disruptive events on  
10 changes in water table height and changes in the flow system.

11           So that's all I have.

12           PARIZEK: Thank you, Bill. Any questions from the  
13 Board? Yeah, Dan Bullen?

14           BULLEN: Bullen, Board.

15           Could you go back to your convolution integral  
16 method, Viewgraph Number 7 of 11? And maybe I'm a little  
17 dense in trying to figure out exactly where you're going to  
18 use the expert elicitation inputs, but could you sort of  
19 describe that to me with respect to how it fits into this?  
20 And maybe another comment might be that when you're finally  
21 presenting this in the VA, transparency is sort of a key, and  
22 I know that mathematically people would understand what  
23 convolution integrals are, but describing how you're going to  
24 mix the two at the interface, or whatever, is going to be an  
25 important factor. So being a little more transparent might

1 be a little helpful. But maybe you can start by telling me  
2 what expert elicitation data will be used and where, and then  
3 just a little advice on the transparency issue.

4       ARNOLD: Okay, yeah. I wasn't really clear in my  
5 explanation of this. This is not really related to the  
6 expert elicitation. This is just an explanation of how we're  
7 performing the calculations. So there is no direct input of  
8 the expert elicitation in this.

9       BULLEN: Okay. And then I guess the follow-on from that  
10 would be that you showed us a nice example, but it seemed to  
11 me the experts didn't have plumes that were 2 kilometers wide  
12 when they got out into the area. But you were just giving us  
13 an example of a sample calculation. The real calculations  
14 will have thinner, smaller plumes that will ultimately hit  
15 the accessible environment?

16       ARNOLD: Not in the Base-Case. What I showed you is  
17 what's being simulated for the Base-Case analyses.

18       BULLEN: So the red plume that comes out for the Base-  
19 Case is pretty big; is that not correct?

20       ARNOLD: by the time it gets to 20 kilometers, it's on  
21 the order of 7 kilometers wide and 500 meters deep. You have  
22 to remember the footprint of the repository is on the order  
23 of 2 to 3 kilometers wide.

24       BULLEN: Right. But as I understand the site scale  
25 model today, it looked like there were a lot of fractures

1 that might have been flowing through there. How do you  
2 basically take a fast fracture pathway out of the repository  
3 horizon and take it to the saturated zone and then get it  
4 out? I mean, the indications of maybe the effects of faults  
5 on the focusing of flow and things like that this morning  
6 don't look like they're represented here. And so when you  
7 see something like--well, I'll throw it to the experts and  
8 ask the experts if they think there's going to be a plume for  
9 a Base-Case analysis that's a couple kilometers wide?

10           Allan, do you think so?

11           FREEZE: Well, I guess it would depend on the nature of  
12 the source. That's always been another source of  
13 uncertainty. The question might be are you going to be  
14 looking at different sizes and sources.

15           ARNOLD: I could provide a little more detail on what  
16 we're doing here. Think of the whole thing, all going at  
17 once and they're all, you know, the whole--

18           BULLEN: Well, I guess my perspective is that even if  
19 they all go at once, what's going to come out is going to  
20 come out where it flows. And if it comes out where it flows,  
21 then it looks more like, you know, sort of discrete sources  
22 as opposed to some smeared source over a couple of square  
23 miles.

24           ARNOLD: Well, let me give you a little more explanation  
25 to this figure. That's what we're doing; we're considering

1 six different sources at the footprint of the repository.  
2 This is a composite of all six of those zones, which  
3 effectively gives you a source that's 2 to 3 kilometers wide.  
4 But we have sub-divided this at least to the extent of  
5 defining six different zones, and transport from those six  
6 different zones is evaluated separately in the calculations.

7 BULLEN: Okay, maybe I'm asking something--

8 FREEZE: I think the point is well taken. It doesn't  
9 look like those diagrams that I showed from Whitmeyer and  
10 from Schwartz and Sudicky, which kind of had tubes, you know.

11 BULLEN: A few hundreds of meters wide, not thousands of  
12 meters wide or something like that. That looks a lot  
13 different than the representation that was shown earlier, I  
14 guess, is the concern I have.

15 ARNOLD: It is in the sense that this is not considering  
16 the limited transverse dispersion that--

17 BULLEN: That the experts have come up with?

18 ARNOLD: That the experts are proposing. But that will  
19 be evaluated in the sensitivity studies.

20 BULLEN: Okay. One more follow-on question and then  
21 I'll stop. You did make a comment about when you're doing  
22 your sensitivity analysis, that in the Base-Case there is no  
23 uncertainty in the flow path?

24 ARNOLD: That's right.

25 BULLEN: Could you explain that to me? How could there

1 be no uncertainty in the flow path for the Base-Case? You  
2 know exactly where it's going to be and what the shape is and  
3 the distribution and all that? I mean, just based on the  
4 models that you've picked, that's dictated--you can't  
5 introduce any uncertainty; is that what you're saying?

6       ARNOLD: That's right. The way we're doing the  
7 calculation, we are not introducing uncertainty in the flow  
8 path in the Base-Case analysis. We're not claiming that  
9 there is no uncertainty.

10       BULLEN: Okay. I misinterpreted what you said, because  
11 you said there is no uncertainty, and I was going, boy, I'm  
12 still uncertain. But you're not introducing any uncertainty,  
13 but you will do sensitivity studies that will address the  
14 issue?

15       ARNOLD: That's correct.

16       BULLEN: Okay, thank you.

17       PARIZEK: Alberto Sages?

18       SAGES: Sages. In this transparency that shows the 20  
19 kilometer plume, is the area of highest concentration aware  
20 from the repository because presumably the repository has  
21 stopped ejecting--

22       ARNOLD: No, the sub-site scale model is used to  
23 simulate transport from the repository out to this 5  
24 kilometer fence. The plume is just picked up here and  
25 simulated in the site scale model from this point.

1       SAG<sub>γ</sub>ES: Oh, I see. So conceptually, one should combine  
2 the two plumes to get the entire plume?

3       ARNOLD: At the same scale, I could superimpose those  
4 two figures and show a single plume.

5       SAG<sub>γ</sub>ES: I see. And then on the one that you have next,  
6 the one on the convolution integral, just to make sure I  
7 understand this, you called that--it doesn't show very well  
8 there, but it shows up in the printout, when you call it--it  
9 looks more like a step and the response at the bottom looks  
10 also like a response to a step, not to a pulse. Am I  
11 understanding that correctly?

12       ARNOLD: Perhaps I used the wrong term. It is a step  
13 input.

14       SAG<sub>γ</sub>ES: A step. But how can it be a step and then when  
15 you have the accumulated response, how could it come down  
16 with time?

17       ARNOLD: What's actually done in the convolution  
18 integral method is this break-through curve, the derivative  
19 of this curve is taken at discrete time intervals, and it's  
20 the derivative that's used in the convolution of this signal  
21 with the transport calculations.

22       SAG<sub>γ</sub>ES: Okay. On the flux, which would be what, moles  
23 per meter squared per second or something?

24       ARNOLD: Yeah, or grams per year. It's really an

1 arbitrary--actually in the TSPA calculations, it's taken in  
2 grams per year.

3 SAG<sub>γ</sub>ES: Okay. And once it's turned on, it keeps going  
4 on forever basically?

5 ARNOLD: Well, to derive this generic break-through  
6 curve, yes, that's true.

7 SAG<sub>γ</sub>ES: The one I don't understand is the one to the  
8 right.

9 ARNOLD: This is another component of the analysis.  
10 This is the unsaturated zone transport model, and its output  
11 is this radionuclide mass flux as a function of time.

12 SAG<sub>γ</sub>ES: Yeah, that would be the sum of pulses. I  
13 interpret that as the sum of pulses. So that I understand.  
14 But I don't see the sum of steps.

15 ARNOLD: It's just a numerical integration method that  
16 takes--that breaks this history down into small intervals in  
17 time and tracks the response of the system based on this  
18 generic--

19 SAG<sub>γ</sub>ES: For each one of them; right?

20 ARNOLD: For all of these pulses, and integrates the  
21 result.

22 SAG<sub>γ</sub>ES: Right. Okay, I don't understand it if you have  
23 a true pulse in the top and then a curve of linear response  
24 with a pulse underneath. Maybe that's another transparency

1 question to come up later.

2       ARNOLD: Yeah, overall, this is a short-cut method that  
3 saves us computational time. What we could do is we could  
4 take this radionuclide mass flux history, feed it into the  
5 saturated zone transport model, and go directly to this. But  
6 that would be much more computationally expensive, and we've  
7 done validation runs that show that this method yields an  
8 approximation that's very accurate.

9       PARIZEK: Debra Knopman?

10       KNOPMAN: Knopman, Board.

11                Could you elaborate a little bit more on how you're  
12 evaluating dilution in a pumping well? First of all, what  
13 does the Base-Case look like for that? And then what sort of  
14 sensitivity analyses are you in fact running?

15       ARNOLD: For the Base-Case, we're not including any  
16 additional dilution at the pumping wells.

17       KNOPMAN: Okay.

18       ARNOLD: We're just taking the maximum concentration.

19       KNOPMAN: Okay.

20       ARNOLD: For the sensitivity studies, that's ongoing  
21 work at this time. The NRC has actually done some numerical  
22 studies to look at this question as well. Their results  
23 should be published very soon. We want to take that into  
24 consideration. The basic answer is we're not sure yet.

25       KNOPMAN: Okay.

1           PARIZEK: Other Board questions? Staff?

2                   (No response.)

3           PARIZEK: If not, thank you very much.

4           HOXIE: Can I ask one question?

5           PARIZEK: Yes.

6           HOXIE: Dwight Hoxie, USGS, just one question, Bill.

7                   On the spreading of your plume, did you take into  
8 account numerical dispersion, or is there some of that in  
9 there? Because you're spacing down gradient is 1,500 meters.

10          ARNOLD: That's correct. There's certainly numerical  
11 dispersion in the simulation.

12          PARIZEK: Thank you, Bill.

13                   The next presenter will be Dwight Hoxie, program  
14 activities at Yucca Mountain, addressing key saturated zone  
15 issues. This ought to look at what ongoing studies are being  
16 planned for the program.

17          HOXIE: Good afternoon. I'm glad to be here. About 24  
18 hours ago, I was actually wagering that there was a fifty-  
19 fifty chance that I was going to have a voice today, and so  
20 if I suddenly--if you see my mouth moving and you hear  
21 nothing, you'll know that something went wrong. But anyway,  
22 I kind of apologize for being kind of gravelly, and I was very  
23 much afraid I was going to have to give this talk in sign  
24 language, which is a language I don't know.

25                   Anyway, we're at the end of presentations on

1 saturated zone studies, and so this is kind of a wrap-up that  
2 I have put together, and the way that I would like to address  
3 this is to kind of review some of the things that we  
4 discussed today to try to pull it all together, and I want to  
5 do this in the framework of the key issues that the expert  
6 elicitation panel were given to assess, and so I'm just going  
7 to go run through these, and what I would like you to do is  
8 to say okay, this is all well and good, these are issues that  
9 not only were important to the expert elicitation panel, that  
10 are important to PA, but they are important to the project as  
11 well. So the question is is what are we doing about them?

12           You heard some of the activities that are taking  
13 place, and I just kind of want to go through this a little  
14 bit to let you know that, yes, we agree these are important  
15 and we are doing things. So I'll just go through them one by  
16 one, just say a few things. This will not be an exhaustive  
17 talk at all.

18           So anyway, first of all, our conceptualization of  
19 saturated zone flow, we heard a lot about that today in  
20 various contexts, and of course the way that we develop our  
21 conceptual models and refine them, first of all, is to  
22 collect data on the basis of which we make inferences, and  
23 then of course this is something that I think everyone needs  
24 to realize about the modeling that we're doing, both the  
25 saturated zone flow modeling and the transport modeling, is

1 that we can use the models sort of in reverse. We can use  
2 them as heuristic tools to try to gain a better understanding  
3 of the system, and I will give you indications of where we're  
4 doing this as I go through the talk.

5           We heard a lot about the large hydraulic gradient  
6 today. We have ongoing studies, some that have been  
7 completed in Bore Hole D-2, for example, which is in the  
8 large hydraulic gradient. We are conducting testing as we  
9 speak actually in WT-24 and we have plans to do additional  
10 testing in WT-18.

11           The kind of testing that we are doing is hydraulic  
12 testing. We are also doing geophysical logging, which will  
13 give us some idea of water content profiles vertically down  
14 the bore hole so that we can look for saturated versus  
15 unsaturated intervals, and we're also doing core analysis,  
16 again, in order to measure saturation so that we can look to  
17 see if in fact we have a water table and a saturated zone  
18 beneath it, or if we have a perched water system at that  
19 particular location.

20           So we are trying to determine, trying to  
21 discriminate between some of the various hypotheses that have  
22 been presented today regarding the nature and original of the  
23 large hydraulic gradient.

24           Another issue that of course is very important to  
25 the transport folks is how much water is moving and how fast

1 is it moving beneath Yucca Mountain. We've heard a lot of  
2 discussion of that today, even from the experts themselves.  
3 The thing that I think everyone needs to realize first of  
4 all, the flux is moving slowly enough that it's not really  
5 something that we can measure by a flux meter, for example.

6           What we have to do instead, and this is what was  
7 done, and Allan Freeze discussed that, is that the first  
8 thing we have to do is know what the hydraulic gradient is,  
9 so we can refine our evaluations of the potentiometric  
10 surface again by measuring water levels and bore holes.

11           I just want to mention that we have two new bore  
12 holes that are going to be penetrating the saturated zone  
13 shortly, we hope, and that's WT-24 up in the large hydraulic  
14 gradient, and SD-6 that we talked about earlier today, which  
15 is on the crest of Yucca Mountain. Once we have the  
16 potentiometric gradient, we then have to have hydraulic  
17 conductivity measurements. We heard talks today about the  
18 work that's being done at the C-Well complex to actually  
19 measure hydraulic conductivities in situ. Of course we have  
20 a back log of data from previous testing in bore holes that  
21 we also can access, and we also, as you heard today, are  
22 planning a second testing complex on a large scale, I think  
23 much larger scale than the C-Hole complex, at least according  
24 to the planning to date, and that this will give us more  
25 refined values of the hydraulic conductivities.

1           So once we have a gradient and hydraulic  
2 conductivity, we can multiply the two together to get a flux.  
3 And the way that we normally do this in order to get a  
4 spatial distribution of flux, and we're running transient  
5 simulations, a temporal distribution of flux is to use our  
6 ground-water flow models. So we are proceeding on that  
7 front.

8           The influence of climate change. We heard about  
9 that today. A lot of the simulations that have been done  
10 that include or incorporate climatic change have been based  
11 on models, climate models, future climate models that were  
12 done by NCAR. We discussed that a little bit earlier today.  
13 But the other thing to do is to look at the past as an  
14 analog to what future climates might be.

15           We've had an ongoing paleohydrology, ecological set  
16 of studies, and we're continuing those. Right now, we're  
17 looking at core from Owens Lake to the west of us here a  
18 little bit to try to get a handle on what was going on and  
19 the details of the climate in the past 10 to 100,000 years.

20           Another activity that is ongoing that is continuing  
21 is to look at both modern springs and paleospring discharge  
22 sites to try to infer what climatic conditions were, what  
23 water levels were in the past. And another study that is  
24 going on is to look at the morphology and the geochemistry of  
25 calcite at the water table beneath Yucca Mountain. There are

1 some, what do I want to say, some anomalies there that may  
2 indicate a fluctuating water table over a period of time. So  
3 this may give us additional data, new data, on what water  
4 levels beneath Yucca Mountain might have been. Our best  
5 estimates right now is that in the past, they may have been  
6 as much as 80 to 100 to 120 meters higher.

7           And then of course this is the program that we have  
8 that we talked about earlier this morning where we take our  
9 ground-water flow models, impose a climate change on those  
10 models, that is to say, higher precipitation at higher  
11 elevations, for example, in order to assess what the impacts  
12 might be on the flow system.

13           In talking about our conceptual models of saturated  
14 zone transport, I think one of the exciting things that is  
15 coming out of our program currently, and you heard about it  
16 from Zell Peterman this morning, is looking at the ground-  
17 water chemistry and isotope geochemistry in attempts to infer  
18 what flow pathways might be, flow domains might be, to give  
19 us some kind of ideas what the pathways are down gradient  
20 from Yucca Mountain.

21           Again, we can use our transport modeling in a  
22 heuristic mode to do tracer studies, simulated tracer  
23 studies, and particle tracking kinds of studies in order to  
24 delineate potential transport pathways.

25           And I might just put in a plug. I understand that

1 people have been getting reports on the so-called--now I've  
2 got to remember what it is--S4Z flow model. It's a sub-site  
3 scale model that we developed a year ago, and we have done  
4 some, again, heuristic modeling with faults, and discovering  
5 that in fact we can identify some kinds of at least in theory  
6 anyway, preferential flow pathways that are structurally  
7 controlled.

8           We heard a lot about that today. This is a program  
9 that is not ongoing at the moment, but is probably going to  
10 be resurrected shortly.

11           In terms of trying to get at these quantities, and  
12 I'm hearing that they're in some sense maybe kind of nebulous  
13 quantities of dilution factors and dispersivities, again, the  
14 way we get at these kinds of numbers, as you heard this  
15 morning, is doing testing, tracer testing, for example, at  
16 the C-Wells, and again probably at the planned second testing  
17 complex.

18           I think we can also probably get some ideas of what  
19 the dilution factors and dispersivities might be by looking  
20 at our ground-water isotope geochemistry, attempting to use  
21 the isotopes as tracers themselves, perhaps using our  
22 transport modeling capabilities to try to invert the problem  
23 and back out the kinds of transport properties that we might  
24 expect.

25           We talk about effective fracture density, and I

1 think that the important thing here to recognize is that we  
2 feel that the primary flow pathways within the welded tufts  
3 down gradient from Yucca Mountain are certainly in the  
4 fractured tufts, the fractured welded units. And it's the  
5 fractures that are probably providing the flow zones in the  
6 bore holes, for example, at the C-Holes complex, and at other  
7 bore holes at the site, so that the flow tends to be  
8 channelled into preferential pathways by the fracture systems  
9 and also by the fault systems, and by any kind of zone of  
10 linear zone, for example, of increased or enhanced hydraulic  
11 conductivity.

12           But in terms of actual fracture data down gradient  
13 from Yucca Mountain in the volcanic aquifers, anyway, we have  
14 very little data. Our best data right now is of course in  
15 the ESF, which is actually mostly in the Topopah Spring,  
16 which is the upper volcanic aquifer, not the Crate Flat  
17 Tuffs, which are lower volcanic aquifer. But we can perhaps  
18 make some transfer just on the basis of from one welded tuft  
19 to another welded tuft. But we have a great deal of fracture  
20 data from the ESF.

21           The other thing that's probably important from the  
22 ESF is that we've identified distinct fracture zones, often  
23 times associated with faults. Perhaps we can transfer that  
24 data, at least heuristically, down gradient to try to  
25 incorporate some of the concepts of channelized or focused

1 preferential pathway type of flow. I don't really refer to  
2 it as fast pathway so much as preferential pathway.

3           Hydrochemical transport parameters, again, a lot of  
4 this has to come out of field testing at places like C-Wells  
5 and our second testing complex. We heard this morning from  
6 Arend Meijer about another aspect that might be important to  
7 transport, and that is the oxidation state of the water, or  
8 actually the redox potential of the waters, and that we are  
9 going to try to do this, try to make actual field  
10 determinations of what the redox potential might be in some  
11 selected bore holes by going back in and conducting very  
12 careful experiments.

13           The other things that we are doing, and I know Lynn  
14 Gelhar has some misgivings about the transfer value of this,  
15 but we are continuing laboratory evaluations of first of all  
16 the solubilities of radionuclides to make sure that, or try  
17 to determine just how soluble they are going to be in the  
18 saturated zone environment that we anticipate beneath Yucca  
19 Mountain to try to determine effective  $K_d$ 's to put into our  
20 models to quantify the retardation of radionuclides, and  
21 finally, conducting experiments on colloidal-facilitated  
22 transport. That's been going on at LANL for quite some time  
23 and is continuing, and also is going to be done--some work is  
24 being done at Livermore in order to look at actually further  
25 up in the system, the formations of colloids in the

1 engineered barrier system that then could be transported  
2 through the UZ and into the SZ.

3           I think I would like to simply say that we do have  
4 a program that recognizes a set of key issues. We are trying  
5 to address those key issues by a variety of means, both field  
6 testing, laboratory testing, and through our modeling  
7 program, and the entire intent is to--well, we're just simply  
8 targeting in on trying to reduce uncertainty of the key  
9 issues, key parameters that are going to be input to our SZ  
10 flow and transport models.

11           And I would just like to make a comment on an  
12 observation that Lynn made today that concerned the  
13 performance assessment and the site characterization side of  
14 the house are not well integrated. I think that we've made a  
15 lot of progress in the past couple of years by having these  
16 abstraction testing workshops involving both site and  
17 performance assessment personnel working together, and I  
18 think we're further going to be enhancing that by going  
19 through a revision of our modeling program in order to bring  
20 not only PA, but design, into the actual guidance and  
21 direction of our site process models, the models that feed  
22 into like the SZ flow model, the UZ flow model that feed into  
23 performance assessment.

24           And so with that, I would like to say thank you,  
25 and I'd be happy to entertain any questions.

1           PARIZEK: Board, questions for Dwight Hoxie? Yeah,  
2 Debra Knopman?

3           KNOPMAN: Knopman, Board.

4                   I have two questions. One has to do with timing.  
5 For the project to work through the resolution of these  
6 various issues and your agenda, what's your estimate on when  
7 the bulk of this work would be completed?

8           HOXIE: I think we're targeting much of this certainly  
9 in the time frame for the license application. Some of this  
10 will obviously extend beyond. For example, I'm sure we'll be  
11 doing a lot of testing for a number of years at, for example,  
12 the second testing complex, so that would be going into what  
13 we would call our performance confirmation program. But much  
14 of this testing is, for example, large hydraulic gradient  
15 should be completed prior to the license application.

16          KNOPMAN: Prior to?

17          HOXIE: 2002.

18          KNOPMAN: So the work would be done by 2002?

19          HOXIE: Right.

20          KNOPMAN: Okay. Can I ask one more question?

21                   On your Slide 7 in your discussion about conceptual  
22 models, you used the term heuristic transport modeling.  
23 Would you explain what you mean by that? I know what it is,  
24 but I'm not clear on what you're really doing here.

25          HOXIE: Okay. What I'm saying is is that we introduce a

1 generic tracer artificially into the model. It doesn't have  
2 to be anything. It could be particle tracking, for example,  
3 I would say would be heuristic, just to identify potential  
4 transport pathways.

5       KNOPMAN: Okay.

6       HOXIE: That's what I meant. I was distinguishing that  
7 from, say, simulating neptunium transport, per se.

8       PARIZEK: Other Board questions? Yeah, Allan Freeze.

9       FREEZE: Allan Freeze.

10             Dwight, there's two areas in your program that  
11 strike me as being sort of easy to say and hard to do. One  
12 of them has to do with the testing procedures that you're  
13 going to use in G2-WT-24 and WT-18 to provide an answer to  
14 both whether it's saturated or not saturated. The method  
15 you're proposing, hydraulic testing geophysics and moisture  
16 contents on cores, are all the same methods that have been  
17 used in other holes to try and answer the same kind of  
18 questions, generally with kind of equivocal results, it seems  
19 to me.

20             The second area is the tracer testing at the C-  
21 Wells and the new testing facility. Again, will it be  
22 possible to interpret those results in terms of sorption  
23 versus matrix diffusion versus dispersion and so on, or will  
24 there still be the same kinds of uncertainties that we've had  
25 in the past tracer testings that, you know, provide some

1 information, but don't really answer these kinds of  
2 questions? I guess I'm worried that it's more of the same.  
3 I wonder if you have sort of new methods that are going to  
4 solve these problems, or are they going to be equivocal  
5 results again?

6 HOXIE: Well, I think I will take a hint that I heard  
7 just a little while ago actually from Lynn Gelhar. That may  
8 be the thing to do. We're developing a plan for the second  
9 testing complex, and maybe the advice should be taken that we  
10 should take that plan outside of the Yucca Mountain project,  
11 and gain the opinions of other experts like yourself, for  
12 example, to see if we are planning tests that will provide  
13 that kind of information.

14 FREEZE: I'm not sure there's answers to these  
15 questions.

16 HOXIE: Well, then there may not be.

17 FREEZE: What about the perched, did you feel the  
18 geophysical testing or moisture measurement, is it going to  
19 answer the question or is going to leave us with lots of  
20 uncertainties still?

21 HOXIE: Well, let me talk about history a little bit.  
22 SD-7, for example, we measured saturations on cores, and of  
23 course once we did that, we got a saturation profile that  
24 does indeed correspond to the perched water, and I think from  
25 geophysical logging, we probably can't have that high a

1 resolution, we can't discriminate between 95 and 100 per  
2 cent, but I think from core analyses, I think we now have  
3 honed our skills well enough that we can probably determine  
4 between 100 and 95 per cent. I think we've done that. I  
5 mean, I think that we've encountered certainly in many bore  
6 holes, especially in some of the neutron holes, the shallow  
7 neutron holes, where we see infiltration events simply based  
8 on core analyses, for semi-perched zones, quasi perched zones  
9 at the base of, or at contacts between units, for example.

10               So I think that from looking at the cores, we can  
11 do that.

12           FREEZE: I'm not sure about the geophysical logging.

13           HOXIE: But we've also inferred the possibility--  
14 historically geophysical logging was done in G-2 and it does  
15 sort of indicate that there may be an unsaturated zone  
16 beneath the normal water table. That was encountered in G-2.  
17 So I think we have a hope of that.

18           PARIZEK: Czarnecki?

19           CZARNECKI: This is John Czarnecki from USGS.

20               I just wanted to comment about the G-2 work. If we  
21 can use UZ-14 as a comparison to what we saw in G-2, the fact  
22 that we stopped the upper water producing zones and drilled  
23 through them with a substantially large interval of non-  
24 producing bore holes, if we see those kinds of things in G-2,  
25 I think that will be a very revealing condition.

1           The fact that G-2 is a completely open bore hole  
2 and water could be coming in from the top and we haven't  
3 tested the bottom part, I think we have something to learn.  
4 But only the first third of the tests that we've proposed for  
5 G-2 have been done.

6           PARIZEK: Parizek, Board.

7           There seems to be a distinctive chemistry of the  
8 water under Forty Mile Wash, and we saw that again with  
9 Zell's presentation today. Is there an opportunity to use  
10 that as an analog more or less of what happens to that mass  
11 of water in the direction of regional flow to the south under  
12 Forty Mile Wash to get out some dispersivities?

13           Another way to look at a natural analog; I pushed  
14 for this for maybe the Crater Flats water, you only have two  
15 wells there so you can't really do much with it at this time,  
16 but is there some possibility of using Forty Mile Wash  
17 chemistry as a way to find out how that mass of water evolves  
18 going southward?

19           HOXIE: Well, I'd probably have to defer to the  
20 chemists, of which I am not. But one thing I'd just comment  
21 is that it seems to me anyway that it looks like Forty Mile  
22 wash is a preferential pathway for flow. So it would  
23 probably entail some kind of structural control, but that's  
24 not answering your question.

25           PARIZEK: No, I was looking for the dispersivity

1 possibility.

2 HOXIE: Right.

3 PARIZEK: But just let it maybe be in the program  
4 thought process and we'll ask you next time we see you and  
5 see whether there's any merit to that.

6 Another thing is about this water level 80 meters  
7 or 120 meters higher than the present sometime in the past.  
8 It seems like in the evolution of Yucca Mountain before  
9 faulting, during faulting with mountain uplifting, Basin  
10 range development, and a whole change in the water table  
11 configuration, there should have been a water table signature  
12 higher up in the mountain than presently, 80 or 120 meters.  
13 Is there any evidence of that? It just surprises me that  
14 that doesn't sort of show up somewhere as fuzzy data  
15 somewhere up in the unsaturated zone.

16 HOXIE: Well, I think I can address that, and I would  
17 appreciate comments from the audience. But I think that  
18 actually the faulting and the topography of Yucca Mountain  
19 probably was pretty well established 10 million years ago  
20 because if you go down to Dune Wash or Rainier Mesa, there's  
21 a deposit at Rainier Mesa tuft there that must have been  
22 filling in a topographic low. So I think that the  
23 speculation right now is that the 100 meter rise or so  
24 represents something that is probably a 10 million year old  
25 type of feature.

1 PARIZEK: Thank you. Staff? Any Staff questions? Yes.

2 REIMUS: Paul Reimus, Los Alamos.

3 I'd like to address Dr. Freeze's question, as well  
4 as some of Dr. Gelhar's concerns, at least with respect to  
5 the C-Wells tests and the second testing complex.

6 Specifically to address your question about new  
7 ideas, new thoughts, there's actually a lot of ideas and  
8 thoughts that aren't entirely new, been around a number of  
9 years on the project, that we would like to pursue at both  
10 the C-Wells and the second testing complex to address these  
11 issues of, for instance, matrix diffusion and sorption.

12 One of those ideas, just as an example, is to  
13 conduct tests at similar in configuration but at different  
14 flow rates to sort out matrix diffusion effects.

15 Dr. Gelhar's comment about using tracers with  
16 greater contrast and diffusion coefficient is another thing  
17 we would like to pursue. There are some definite physical  
18 and chemical constraints there. As you try to get larger and  
19 larger diffusion coefficient contrasts relative to say a  
20 simple anion like bromide, you're talking about bigger and  
21 bigger molecules, bigger and bigger molecules always tend to  
22 sorb more, and so forth, and so there's that problem.

23 But there's also, you know, another way of looking  
24 at matrix diffusion that a lot of people advocate, is doing  
25 single well injection withdrawal tests. These have been

1 proposed on the project for a number of years. They've been  
2 done successfully by the WIPP project, for instance. So  
3 these are other ideas.

4           Also, the thoughts of going to larger length scales  
5 and doing tracer testing and doing more recirculation,  
6 approaching what Dr. Gelhar suggests, basically a full dipole  
7 test, are certainly thoughts on the table as well. These  
8 things do boil down of course to time and money, and that all  
9 has to be considered as well.

10          PARIZEK: If there are no other questions, we'll go to  
11 our final presenter, Robert Yasek, who'll talk about thermal  
12 testing program and an update. It's above the saturated  
13 zone, but it goes to the large heater experiment, and a  
14 chance to look for some new input or data. After that,  
15 hopefully it will still allow time for public comment or  
16 input before it all closes down. And the sun is setting, but  
17 I hope that everybody gets a new appreciation of the desert  
18 based on today's presentation. A lot going on below our feet  
19 as we travel through this country. Bob?

20          YASEK: Good evening. My name is Bob Yasek. I work for  
21 the Department of Energy on the Yucca Mountain project, and I  
22 will be updating the Board on the thermal testing program at  
23 Yucca Mountain.

24               Basically, I'll be going over the large block test,  
25 the single heater test and drift scale test, and some of the

1 results that we've seen from each of them, and the progress  
2 of them.

3           Here's a picture of the large block test. The  
4 objectives of the large block test are to look at the thermal  
5 effects of the hydrology of the near-field environment and  
6 look at such things as dryout and condensation, looking at  
7 condensate refluxing and some of the chemical and mechanical  
8 responses to each of these.

9           The schedule for it currently is we are in the  
10 cooling phase, or we will be initiating the cooling phase  
11 later this month or in early February, and that will continue  
12 through the end of the fiscal year. Post-test  
13 characterization for this will begin in early FY-99, which  
14 will be in October.

15           This is the layout of the large block test. In the  
16 diagram on the left, the dominant face is the east face here  
17 into which the heaters are placed, and the dominant face here  
18 is the north face looking to the south.

19           Currently, the maximum temperatures are being  
20 maintained between 135 and 140 degrees C. And we have  
21 levelled off as seen in RTD at TT1-14. This, if you are  
22 looking at plan view with the north to the top, would be  
23 roughly within a meter of the center of the block to the  
24 northwest of it, and basically it shows where it levels off  
25 at roughly 135, about 135 degrees.

1           In TT2-14, it shows similar. This is out closer to  
2 the edge on the eastern side of the block, and it shows a  
3 little lower temperature, which could be due to the fact that  
4 it's closer to the edge, getting some boundary effects there.  
5 And both of these are from vertical bore holes.

6           Some cooling in the power ramp down period is seen,  
7 but the temperatures are now relatively constant. This is  
8 through the 10th of December, and we see this levelling out.  
9 This break here is at about New Year's, and this is just  
10 before Christmas and indicates some internal event.

11           Looking at the hydrology of the large block test,  
12 using ERT, electrical resistance tomography, they suggest  
13 that there's a region of dry rock has formed around the  
14 heater where up to 80 per cent of the original water has been  
15 lost. And in some vertical features down here on the bottom  
16 here, we have a saturation model, a region of increased  
17 saturation is seen locally and situated vertically. And this  
18 came up during a time of possible significant hydrological  
19 event, which occurred about June 13th. This was taken on the  
20 25th, this tomograph, which was shortly after it. And the  
21 middle row indicates the temperature within the block.

22           Moving on to mechanical effects, this, which  
23 doesn't show up very well, this face right here is the  
24 eastern face. Some of the results seen in the mechanical;  
25 all instrumented fractures have opened since the start of

1 heating, and a sub-horizontal fracture, which is basically  
2 this plane here, this is the east face, this is the south  
3 face, has shown movement to the east, top to the east.

4           Also, a north-south feature which runs roughly here  
5 has shown significant movement with the west block moving  
6 down relative to the east, which is moving up.

7           Thermal perturbations happened at about 2,500  
8 hours, which is roughly about the June 13th event, and was  
9 preceded by an acceleration of fracture openings and sliding.  
10 This deformation is known to increase the fracture  
11 permeability, suggesting mechanical response, may have  
12 contributed to thermal hydrologic behavior.

13           Moving on to the single heater test, the objectives  
14 of the single heater test remain to assess the  
15 thermomechanical response of the Topopah Springs to a linear  
16 heat source, enhance our understanding of coupled processes  
17 in an intermediate field scale test larger than the large  
18 block test, and shakedown of our instruments to be used in  
19 the drift scale test.

20           The cooling phase currently has ended and the  
21 insulation has been taken off. That was taken off in early  
22 January, on the 5th, and that acquisition system will  
23 continue through early February when post-test  
24 characterization will start. And some of the significant  
25 activities we'll be doing with that will be overcoring of

1 heater bore holes and hydrology bore holes, and looking  
2 specifically at the Bore Hole 16 where water was taken out  
3 of. Air injection, gas tracer, Goodman Jack testing, rock  
4 bolt pull tests, both on the ambient and on the heated side  
5 of the drift, all these to compliment studies that were done  
6 prior to and during the test itself.

7           Okay, other information, other studies to be done  
8 in the single heater test, post-characterization, mineralogy-  
9 petrology analysis, laboratory hydrologic properties,  
10 evaluation of heater and instrument performance, perhaps to  
11 help in the drift scale test, and laboratory thermal-  
12 mechanical properties. All this will be wrapped up in a  
13 report that will be done next January. And here's a layout  
14 of the single heater test.

15           Some of the things seen in the predictions versus  
16 measurements are that the measurements agreed quite well with  
17 predictions, and show that heat transfer is dominated by  
18 conduction, but it's important to incorporate hydrology into  
19 the model predictions and analyses.

20           This is looking to the south--or rather into the  
21 block, the heater, if you were standing at the heater source  
22 here looking in. Drift scale tests will be down this drift  
23 and the alcove goes around this side here. This is  
24 predictions and measurements. And as you see, they agreed.  
25 They agree well.

1            Looking at a single thermocouple, the measured  
2 response is in red, and it agreed reasonably well with the  
3 predicted data. Permeability was not included in this and we  
4 were to assume that only conduction was involved in the heat  
5 transfer. They tend to over predict, so there would be  
6 likely a line higher above here. So it's clear that  
7 something besides just conduction alone is involved in heat  
8 transfer.

9            And looking at measured versus predicted for  
10 mechanical, again we see responses that are consistent with  
11 predicted.

12           Looking at ERT for the single heater test, we show  
13 significant dry-up occurred around the heater during the  
14 heating phase, and re-wetting conditions continue to progress  
15 during the cooling phase.

16           These first two, the first line there shows the  
17 resistivity ratio, and then temperature. And then the  
18 saturation model, the first model is assuming that conduction  
19 of electricity is primarily through the pores, and model two  
20 assumes surface conduction. And model two generally seems to  
21 provide better results, and these are based on Waxman and  
22 Schmidt's equations.

23           Looking at the geochemistry of the single heater  
24 test, hydrology and geochemistry, what was collected on four  
25 occasions from Bore Hole 16-4, approximately five liters each

1 time on three occasions and one and a half liter was  
2 collected on February 27th, probably because it was only less  
3 than a month between collections from sample two to sample  
4 three.

5           There was no significant accumulation of water  
6 after the heating phase was terminated. However, note that  
7 it did go up slightly here, and then on this--this was  
8 collected on the 22nd and less than a week later, the heaters  
9 were turned off. There was some up turn. Then as soon as  
10 the heaters were turned off, it dropped off very sharply.

11           But the water chemistry was consistent with  
12 condensate origin and interaction with fracture-lining  
13 minerals along the flow path. Length-scale of the flow path  
14 was on the order of meters, roughly 3 to 6 meters, and based  
15 on reactive transport modeling.

16           And, finally, I'll update you on the drift scale  
17 test, which the objectives are to predict and measure coupled  
18 processes at the scale of an emplacement drift, looking at  
19 temperature distribution and heat transfer modes, propagation  
20 of drying and re-wetting regions, changes in the water  
21 chemistry and mineralogy, and thermal expansion and  
22 deformation modulus.

23           There's what's commonly called the "Pick up Sticks"  
24 diagram of the drift scale test, showing all the multiple  
25 bore holes and their purposes.

1           This test was started on December 3rd. Current  
2 plan calls for a four year heating process. Data collection  
3 and analysis is ongoing. Our first report is due this  
4 September.

5           Some early observations out of the drift scale test  
6 show basically no surprises. Baseline and initial hearing  
7 phase measurements have been recorded. They show anticipated  
8 behavior. All the equipment appears to be working in the  
9 manner consistent with what we expect. And basically the  
10 instruments are still within an area that is within ambient.  
11 So thermal perturbation hasn't reached the outermost part of  
12 the instrumentation yet.

13           This information, the temperatures range from 75 to  
14 82 as of January 5th. As of this past week, I would say that  
15 would be about 84 and 90 degrees C, roughly, and of course  
16 rising. And so far, we haven't seen any responses in any of  
17 the hydrology bore holes that indicates water accumulation  
18 like we saw in the single heater test, those types of  
19 responses.

20           The power has remained relatively constant. The  
21 wing heaters in red above are operating at 100 per cent of  
22 power, and the canister heaters in the drift itself are  
23 operating at 80 per cent of power. This will continue at  
24 least through one year, and it will be evaluated whether or  
25 not the power should be adjusted at that time.

1 Trace and data from several bore holes, the first  
2 graph shows data from within the drift itself on one of the  
3 canisters and in the air, showing the heat-up.

4 SAG<sub>γ</sub>ES: Excuse me. I don't understand. Where is that-  
5 -

6 YASEK: This is about halfway down the drift. One of  
7 the air ones, which is in blue, is a thermocouple that's just  
8 out in the air.

9 SAG<sub>γ</sub>ES: Like in between the two packages?

10 YASEK: Exactly. And I could get you more specifics on  
11 the exact location of that, but I believe it's between 4 and  
12 5.

13 SAG<sub>γ</sub>ES: And the floor heater, what--

14 YASEK: And the floor heater, that's on the surface of  
15 the heater itself, the surface of the simulated waste  
16 container.

17 SAG<sub>γ</sub>ES: Now, the containers are simulated containers;  
18 do they have heaters inside?

19 YASEK: They have heaters inside of them, yes.

20 SAG<sub>γ</sub>ES: And what is the floor heater again?

21 YASEK: A floor heater, it's a metal mock-up,  
22 approximately the same size that we would expect a container,  
23 a waste container to be, and it contains 30 heaters located  
24 around the inside of it, evenly spaced.

1 SAG<sub>γ</sub>ES: So those are inside a simulated package?

2 YASEK: The heaters are inside the steel containers.

3 SAG<sub>γ</sub>ES: Okay. And that's a thermocouple in one of  
4 those heaters inside the containers?

5 YASEK: At the surface of the container, on the outside.  
6 There's a thin wall, probably a quarter inch of steel  
7 between the inside of the heater and the outside where the  
8 thermocouple is located.

9 SAG<sub>γ</sub>ES: So that would be equivalent to a container's  
10 surface temperature; is that correct?

11 YASEK: That is correct.

12 SAG<sub>γ</sub>ES: Okay, thank you.

13 YASEK: Okay, this graph was taken from data taken from  
14 this vertical bore hole in yellow located about midway down  
15 the drift, and it shows a response. These RTDs are spaced  
16 about 30 centimeters apart, the first RTD being at the collar  
17 of the bore hold, and shows a rapid response. As we get  
18 further in, the second RTD shows a much more subtle response,  
19 and beyond that, there may be a break in RTD-20, and by the  
20 time we get down to RTD-30, there's no response. But it is  
21 showing a smooth response.

22 SAG<sub>γ</sub>ES: I understand the blue curve, but the other  
23 ones, could you indicate in the diagram on the right where  
24 the thermocouples for those would be located?

1 YASEK: Okay. The thermocouples for those, let's see,  
2 the first one would be right at the top of the drift here.  
3 Right there. Thermocouples are located every 30 centimeters  
4 throughout this. So RTD-10 would be roughly 3 meters in. So  
5 this is a 20 meter bore hole, so it would be about a seventh  
6 of the way, it would be just below the T on drift there on  
7 that vertical bore hole.

8 SAGYES: Okay. And the others are higher up?

9 YASEK: That is correct.

10 SAGYES: I see. Thank you.

11 YASEK: On the bore hole that is parallel to a wing  
12 heater, and that would be on this bore hole right here, again  
13 we're seeing responses. Right here, RTD-40 has some unusual  
14 inflections and at this time, this is data that's probably  
15 less than three weeks old. It's just the only thing that I  
16 could tell you about that is that it indicates that there's  
17 something other than just conductance of heat.

18 This is from the bore hole that's parallel to the  
19 drift right along here. This RTD-1 here is right at the  
20 collar, and generally would show the ambient temperature in  
21 the drift. And then RTD-10 is further in. These are located  
22 at one meter spacings, and so RTD-10 actually doesn't reach  
23 the wing heaters yet. These wing heaters are coming out to  
24 the side here. RTD-10 would be somewhere in this region  
25 right here.

1           Now, once you see RTDs where you're reaching the  
2 wing heaters, then we show an elevation in temperatures,  
3 basically showing that there aren't any surprises so far, and  
4 that the drift is heating up.

5           These are along the surface of the roof of the  
6 drift in a line along here, and showing temperatures along  
7 the drift are increasing since turn on. And an interesting  
8 thing to note is that it appears that it's a slight bit  
9 warmer near the bulk head than it is toward the back of the  
10 drift.

11           And, finally, looking at a hydrology bore hole,  
12 which is this blue one right here, so far, we've seen  
13 responses which are not inconsistent with that which we would  
14 expect from barometric pressure. I haven't seen any  
15 responses like in Bore Hole 16-4 in the single heater test  
16 where we might expect to see some fluid build-up, some water  
17 build-up.

18           And that concludes my update of the thermal testing  
19 at Yucca Mountain.

20           PARIZEK: Thank you, Bob. Any questions?

21           BULLEN: Bullen, Board.

22           Can you go back to the large block test?

23           YASEK: Yes.

24           BULLEN: Interesting anomalous outputs, and describe for  
25 us, if you will, a little bit more about what you think

1 happened at 2,500 hours and again at it looks like about  
2 4,500 hours.

3 YASEK: Okay. At 2,500 hours, that was roughly June  
4 13th, there was--this probably shows it best right here.  
5 There was a hydrologic event. It rained within the vicinity  
6 of Yucca Mountain. There wasn't a rain gauge right at the  
7 large block test, so we don't know exactly how much rain fell  
8 right there. But the response of this was believed to have  
9 been caused possibly by that event.

10 Again, there was at 4,500 hours, this was roughly  
11 Labor day, just after a Labor Day weekend on I believe  
12 September 2nd, there was another similar event where the  
13 temperature went down again. I also might add that at this  
14 point right here, there was a chiller failure. The heat  
15 exchangers that are on top of the large block failed, and so  
16 there's some possibility that played in a role in it, but  
17 also this event here, there was no chiller failure there.  
18 But at both of these, this event here I believe that Yucca  
19 Mountain had several inches of rain within a 24 hour period.

20 BULLEN: This was the hurricane that came in from the  
21 Gulf of California?

22 YASEK: I believe so. September 2nd, it was right after  
23 Labor Day, on a Sunday, I believe.

24 BULLEN: Could you comment on the other thermocouples  
25 that you had, the other RTDs, these are temperatures that are

1 in the hot zone. What were the other kinds of temperatures  
2 that you had? I mean immediately below the heaters, what was  
3 the temperature response associated with these anomalies?

4 YASEK: Okay, I haven't seen those, but, for example,  
5 this is further off to the side. Generally, I believe that  
6 if they hadn't reached the boiling point, that we didn't see  
7 a response like here, however, at this one, since it had  
8 reached above the boiling point here, we're seeing some of  
9 this noise which is similar to that which we had over here.  
10 And also it shows the September 2nd event there as well.

11 BULLEN: So you think the noise could be associated with  
12 the heat pipe type effect where you actually have a boiling  
13 front that's moving back and forth along fractures nearby the  
14 RTDs? That's a lot of speculation on your part, I realize.

15 YASEK: That's a lot of speculation. Right now, like I  
16 say, we don't have rain data for right at the site there, so  
17 we can't positively say that it was water, it was rainfall  
18 that caused these events.

19 After this September 2nd event, the top of the  
20 block was covered to prevent any further rainfall from  
21 possibly getting any water into the--

22 BULLEN: One last question, and then I'll yield to my  
23 distinguished colleagues here.

24 On the drift scale heater tests, the initial data  
25 that you're collecting, does it also include relative

1 humidity data, partial pressure of oxygen, partial pressure  
2 of CO<sub>2</sub>, partial pressure of water vapor within the drift, and  
3 do you have any information on that? Or that's a preview of  
4 coming attractions we can see at a later date?

5 YASEK: It does have relative humidity, and such. And  
6 that's probably something that we will be coming out with at  
7 a future date.

8 BULLEN: Okay. I just wondered. In all the data  
9 acquisition besides the temperature data acquisition, have  
10 you seen any surprises, is my question?

11 YASEK: I haven't seen data, so I can say no.

12 BULLEN: Okay. Well, I'll bother Bill Boyle about that  
13 later then.

14 PARIZEK: Paul Craig?

15 CRAIG: Craig, Board.

16 I'm interested in understanding, your level of  
17 understanding of the mechanisms that are going on, and  
18 there's two questions along those lines. Probably at the  
19 level of Yucca Mountain, the boiling point of water is maybe  
20 98 or so C?

21 YASEK: That sounds reasonable.

22 CRAIG: And it looked from the graphs with the  
23 resolution that I could see from here, that on both occasions  
24 when you had your rain storms, the temperature  
25 instantaneously dropped to the boiling temperature. It sure

1 looks to me like right there, it dropped to 98, and right  
2 over there, it dropped to 98 instantly on the resolution of  
3 that. You probably have higher resolution. That sort of  
4 suggests that there are some big cracks there through which  
5 the rain can get in very, very fast. That sounds like  
6 something one could model, so that's one question.

7           The second question is in talking about your  
8 understanding of these graphs, you said, if I understood you  
9 correctly, that everything could be understood--well, first  
10 of all, you said it wasn't just thermal conductivity; that it  
11 was more complicated effects. But interpreting what I  
12 thought you were saying, thermal conductivity, the heat  
13 capacity of the medium and the latent heat of the water would  
14 appear to be the primary physical phenomena, and that's  
15 straightforward enough.

16           YASEK: Right.

17           CRAIG: Are there other physical phenomena that you're  
18 modeling, or is that the full extent of it?

19           YASEK: Other--okay, we're also looking at fractures of  
20 the block. I'm sorry, I lost my train of thought.

21           CRAIG: The question is what are the physical mechanisms  
22 that you're modeling here, and do they include phenomena  
23 other than thermal conductivity through the rock and  
24 evaporation of the water?

25           YASEK: Yes. As a matter of fact, this event here was

1 preceded by the mechanical event where there was a mechanical  
2 perturbation prior to that where fractures opened up,  
3 possibly allowing water to go in.

4 CRAIG: That's for the abnormal event.

5 YASEK: That's correct.

6 CRAIG: Presumably you're measuring that.

7 YASEK: Yes.

8 CRAIG: But for the normal behavior when you don't have  
9 a crack, are there any other mechanisms when you don't have a  
10 failure where you heat it up and it cracks, are there other  
11 physical phenomena that you're modeling besides the one that  
12 I mentioned? What goes into the physical models when you do  
13 all these--we measured this, we predicted that. I'm trying  
14 to understand what went into the model that produced the  
15 curve with which you compared the experimental data in order  
16 to say that the agreement was good. Is there anything that  
17 went into that beyond the thermal conductivity of the rock,  
18 the heat capacity of the rock, and the latent heat of water?

19 YASEK: Okay.

20 CRAIG: Specific heat of water, too.

21 YASEK: Okay, I'd probably have to get back to you on  
22 that one.

23 CHESTNUT: Duane Chestnut from Lawrence Livermore Lab.

24 There is no quantitative analysis yet of what  
25 happened on this test, but I think we have a reasonable

1 speculation about what happened. There is a report available  
2 on CD ROM now called thermal coupled processes that has  
3 somebody's temperature curves and some discussion of what we  
4 think happened.

5           In addition to that, there are some videos showing  
6 some lab scale experiments that were done at Lawrence  
7 Berkeley Laboratory with pentane in an artificial fracture.

8           What's happening is you have a system that's  
9 gravitationally unstable. You're heating from below. You  
10 have a dry-out zone, and up above that, the water that has  
11 been evaporated is collecting somewhere up in the rock, and  
12 this first event here seemed to have been triggered by a  
13 failure of the upper heat exchanger at the top of the block,  
14 which I think allowed condensation to occur. It overloaded  
15 the capacity of the fractures to sustain that thing against  
16 gravity drainage, and so you have water cascading down into  
17 the hot zone and then evaporating rapidly and being blocked.

18           So we've got basically a percolator, thermal siphon  
19 effect going here, and I think that's why you see these  
20 extremely rapid--there's no other mechanism we could think of  
21 that would lead to such rapid changes in temperature, other  
22 than advective movement of water, followed by rapid boiling,  
23 and this is exactly the picture you see in these little lab  
24 experiments that I mentioned.

25           Now, in order to get a model of this thing, we

1 would really have to have a very detailed dual porosity model  
2 with fractures in the matrix adequately represented in this  
3 thing, but we have to have the relative permeability  
4 characteristics of the fracture, so without the thermal  
5 hydrologic properties in addition to all of the basic thermal  
6 properties. So I think that's kind of where we are on the  
7 thing.

8       CRAIG: That's very helpful in the unusual event. Now,  
9 what about normal behavior when you don't have rain and you  
10 don't have cracking? What else goes into the model?

11       CHESTNUT: Well, what--

12       CRAIG: Are there any other physical mechanisms?

13       CHESTNUT: What do you mean by normal behavior? I mean,  
14 this--

15       CRAIG: Well, behavior excluding the events that  
16 occurred--

17       CHESTNUT: No one modeled this before we saw it happen.  
18 Okay?

19       CRAIG: Pardon?

20       CHESTNUT: No one modeled a temperature curve that looks  
21 like this before we actually saw this.

22       CRAIG: Well, take this section over here.

23       CHESTNUT: Now, right here, the system is--basically  
24 it's a conduction dominated system.

25       CRAIG: Are there any other physical phenomena besides

1 the ones that I mentioned that you include?

2       CHESTNUT: What you have is a pure heating problem. And  
3 remember that up until we hit 100 degrees, we're really  
4 drying out that part of the rock. So that's essentially a  
5 single phase system. Now we've created a system where we've  
6 got a dry region building up around the heater. That water  
7 has to go someplace, and some of it goes above the heater  
8 plane and some goes below. What goes below doesn't bother us  
9 because it runs out the bottom of the system. It's the stuff  
10 that's up here that has this--it's been sitting there waiting  
11 to come down as soon as something perturbs it, and I think  
12 what happened is you see this plateau, you have a long period  
13 here where we're right at the boiling point. That's a two  
14 phase region where we have both liquid water and vapor  
15 present, and finally we dried out all the water in that  
16 particular thermocouple location and we started to come up  
17 with another conduction heating. So now we have a dry system  
18 essentially with water vapor in it, and that continued until  
19 something happened at the top that caused water to come back  
20 down into that hot zone.

21       CRAIG: And you were able to quantitatively model all  
22 those processes?

23       CHESTNUT: I'm saying we have not quantitatively  
24 modeled. This is part of the work that's in progress now.  
25 Now that we've seen the occurrence and we know we have to

1 take this kind of thing into account--

2       CRAIG: Well, I remain confused because there was a  
3 graph that showed temperature distribution experimentally and  
4 temperature distribution observed, and the assertion was made  
5 hat the agreement was excellent.

6       CHESTNUT: In the single heater test.

7       CRAIG: Okay.

8       PARIZEK: I would recommend that since this is a  
9 progress report, a lot is going to be going on in the months  
10 ahead and we'll have a chance to come back to this, and it's  
11 more important now that we do allow time for public comment,  
12 and that will be chaired by our chairman.

13                Meanwhile, I want to thank all presenters for an  
14 immense amount of effort to get all of this across in the  
15 time period available. I said it would be dark when we were  
16 finished, and I'm right on schedule, but again I thank the  
17 audience for staying with us and being patient.

18       COHON: My thanks also to the many speakers that we had  
19 today, and to Richard Parizek for his fine job of chairing  
20 the sessions and for keeping us right on schedule. It is  
21 indeed dark.

22                Well, clearly, as we've learned today, the  
23 saturated zone is an area of keen and active interest with  
24 the program, as well it should be. It's also an area where  
25 there's a great deal of activity still shaking itself out.

1           I'm now going to call on people who have signed up  
2 to make comments or to ask questions. First, Sally Devlin.

3           DEVLIN: Here I am, Dr. Cohon, and of course I want to  
4 give you a toastmaster's evaluation, and that is that we  
5 really welcome you to Amargosa. We hope you'll come back.  
6 We hope next time it will be Pahrump and you can enjoy our  
7 hospitality there. And I hope you enjoyed the weather we  
8 brought you and I hope it stays this way.

9           Your joke is ready and my friend with the beard up  
10 in front has it for you. My comment on the program is that,  
11 one, it's much too long. Is there anything that can be done  
12 so that there isn't 15 presentations, lunch, breaks and so  
13 on? Can we tape it? Can you do it elsewhere and bring it  
14 all together? Can something be done electronically? I know  
15 I'm broken, and I can imagine how broken you all are, and  
16 then you have to fly out. I'm asking you that question.

17          COHON: Your observation is duly noted. I'm sure we're  
18 all feeling that way.

19          DEVLIN: Okay. And I think it's something to be looked  
20 into, because if we had the full day yesterday, perhaps it  
21 wouldn't have been so congested today.

22          COHON: It's a fair point. Thank you.

23          DEVLIN: The other thing is I give my best speaker to  
24 Lynn Gelhar. Is he here? I think he's gone back to MIT.

25          COHON: I think he might have left.

1           DEVLIN: Anyway, the reason that I'm doing it is he  
2 really had doubts about Yucca Mountain, and you know how I  
3 feel about you, you're going to kill us all and the entire  
4 world if you get water in those radionuclides, and so I  
5 really feel that you've had a grand time doing modeling, and  
6 it really rather disturbs me because there's nothing wrong  
7 with modeling. I took a computer course seven semesters ago  
8 and I have a 286 word processor. We have no wiring to get  
9 internet where I live, so I'm kind of stuck with that. But  
10 what is bothering the most, the first thing I learned from my  
11 teacher is garbage in, garbage out. And of course he went to  
12 jail for life. So I'm just saying I'm hearing too much of  
13 this modeling. I've seen too much of the modeling, and I'm  
14 concerned that you want reality to live up to your models.

15           When Russ said about, well, we're going to do the  
16 model before we go into the east-west drift, this really  
17 bothers me. Models have their purpose, and I think it's  
18 wonderful that you have probably many millions of dollars of  
19 computers, but I didn't see this is that color, this is that  
20 height, this is so on, and I want more heat testing, and I  
21 want more age testing, and I want more flow testing. But I  
22 want it no on a model. I want it in reality, because as far  
23 as I am concerned, and I go way back with John, when some guy  
24 did a 40 minute presentation with every crack, fissure, what  
25 have you, in the world at Yucca Mountain, and he said where

1 did you do it, and he said I did it in the lab.

2           You've got to do these things in real life, and I  
3 do believe that the mountain is just one fracture, fissure,  
4 fast flow and so on, and if you had been here, and I will  
5 never invite you to this, and that is when we had the floods,  
6 and we had seven and a half inches of water or more in  
7 Pahrump. You had it out at the test site, too, not as bad as  
8 we had it, but on the desert, we have a different world out  
9 here, and I remember talking to John before they put the  
10 tunnel boring machine in, and I said for goodness sakes, drop  
11 four inches of water on the tunnel before you put it in, and  
12 he said we don't do that.

13           The next year, you had the floods. The roads  
14 washed out. The trucks washed out, all kinds of damage. So  
15 this is the desert and I'm an Easterner, but I've been out  
16 here full-time more than 30 years, and I understand this  
17 desert. You can have a cloud that cries and floods you away,  
18 and that is our desert, and I just want you to make you aware  
19 of it.

20           I always recommend, and that was my recommendation,  
21 and my commend is come on back. I see old friends, Dr.  
22 Chestnut and so many others. I'll have another joke for you  
23 next time. I'll see you at the next meeting in Vegas. But I  
24 really do feel that this is overwhelming, not only with  
25 information, but with modeling, and you might do a little

1 more hard science, and I am afraid of the radionuclides and I  
2 want more cancer things. Nevada has the highest incidence of  
3 cancer for women, breast cancer, and lung cancer, and the  
4 worst in the entire nation, we're number three in the world,  
5 but the worst in the entire nation is the District of  
6 Columbia in every class of cancer. And I am looking for more  
7 radionuclide studies to let us know what these radionuclides  
8 do to our body, what one does to this one and that one, and  
9 so on, and why you die or I die, and nobody knows. And this  
10 is really what the public is I think interested in.

11           So thank you. Come again very soon.

12           COHON: Thank you, Ms. Devlin. Thank you very much.

13           Mike Williams. Mr. Williams, are you still here?

14           WILLIAMS: I spoke yesterday, sir.

15           COHON: Thank you. Earl McGhee.

16           EARL MC GHEE: I'm Earl McGhee. I live in Amargosa  
17 Valley, and I, too, want to thank you very much for having  
18 your meeting here. I appreciate it. I hope that you  
19 understand what the public is trying to tell you. However,  
20 sometimes when you rub elbows with a certain class, whether  
21 you're an engineer, a doctor or what have you, you think  
22 along the same lines and I happen to think a little  
23 different.

24           What Sally said about water, she was at the meeting  
25 at the Mirage in Las Vegas where I asked a question. When

1 the man says oh, it will stand a 6.5 earthquake, and I asked  
2 him, I said, "What happens to the subterranean resource when  
3 you have that seismic activity?" That comes up, and there's  
4 no way to predict that you won't have a 6.5 or even a 7.5 in  
5 the future. There's no way that you can predict one way or  
6 the other. You have Mammoth right now that they're afraid  
7 may boil over and pop its cork. And if that does, you have  
8 your faults here that may become a little active also.

9           It reminds me of what the great--when something was  
10 not with authenticity and not proven, he said God doesn't  
11 roll the dice. It was Albert Einstein. So all the variables  
12 that you have studied I think you'd better take a second look  
13 at the values. I think you do a good job. It's obvious that  
14 you're working. Sometimes--well, it reminds me of an old  
15 story, if I may tell you. It's about a new teacher that went  
16 to a new school and teaching a class in theology, and the  
17 first day in class, he asked the boy, he says hey, Sammy,  
18 stand up and tell me who tore down the walls of Jerico, and  
19 the kid jumped up and screamed at him and says, I didn't do  
20 it. He says, furthermore, if I knew who did it, I wouldn't  
21 tell because I don't rat on anybody. Later, he was having  
22 lunch with another teacher, and he told the teacher about  
23 asking the question and the response he got, and the other  
24 teacher stopped him. He says wait a minute, he says was that  
25 a little fair haired boy with freckles? He said yes, it was.

1 He said, well, if he says he didn't do it, he didn't do it.  
2 And furthermore, if he knew who did, he wouldn't tell  
3 because he wouldn't rat on anybody. This disturbed the  
4 teacher, so he was telling the school administrator, the  
5 principal about it, and the principal listened attentively  
6 and when he was through, he told he, he said, boy, that is  
7 awful. He says it's the worst thing I ever heard. He said  
8 but, however, don't worry about it. I'll have the brick  
9 masons come around tomorrow and put it back up again.

10           Sometimes we can get lost in these things. Well,  
11 there is such a thing as the competent/incompetent, and  
12 sometimes you listen to the incompetent/competent, you might  
13 be better off.

14           On this water thing in Las Vegas at the Mirage,  
15 that's a very serious thing. When I brought up about the EIS  
16 for the test site, Amargosa Valley is in the ambience, and  
17 it's also in the flow pattern, and they needed an alternative  
18 water source, even though they had plenty of water. Now  
19 they're filing on Amargosa water. So think about it. When I  
20 told people about this after I read it, they wouldn't believe  
21 it. So people can stick there head in the sand or wherever,  
22 and they get nowhere.

23           But, again, I thank you and I'm not saying that  
24 you're not working. You people are doing an awful lot.  
25 There is such a thing as work with a positive construction

1 rather than destruction. When you risk a certain area with  
2 wildlife and people, maybe that risk can be avoided. I think  
3 it can be. I thank you.

4 COHON: Thank you, Mr. McGhee.

5 Victoria McGhee could not stay for the public  
6 comment period and she wrote a statement and asked Bill  
7 Barnard, the Executive Director of the Board, to read it into  
8 the record. Dr. Barnard?

9 BARNARD: Thank you. "My name is Victoria McGhee. I  
10 live in Amargosa Valley. My comments are addressed to  
11 everyone at this meeting.

12 Ladies and Gentlemen, you are breaking new ground  
13 at Yucca Mountain. You have a wonderful opportunity to break  
14 new ground in this small community of Amargosa Valley. If  
15 Yucca Mountain is licensed, and I believe it will be,  
16 Amargosa Valley will be in the critical hazard area. I would  
17 urge you to rethink your payment equivalent to taxes  
18 obligations. Amargosa receives no benefit from these monies.  
19 The county has discounted and disowned Amargosa, choosing to  
20 build monuments to themselves elsewhere.

21 Break new ground for the existing population. Stop  
22 making victims of the surround population. That has happened  
23 in Fernald and all the other toxic contaminated sites.  
24 Chernoble residents never recovered. Their injuries are  
25 ongoing and they are still dislocated. There will be

1 accidents. Remember Murphy's law. Take the lead for the  
2 nuclear industry. Use this opportunity to break new ground.  
3 Buy out the residents of this small community. Use Pahrump  
4 as an example of how Amargosa would have developed without  
5 Yucca Mountain, plus a relocation allowance. Live up to your  
6 responsibility to this critical hazard area. Rethink your  
7 obligation. Lead the way.

8 Thank you. Victoria McGhee."

9 COHON: Thank you, Bill. Steve Frishman?

10 FRISHMAN: In the interest of time, I just have one very  
11 short comment. And that's that I think regarding the  
12 viability assessment TSPA, I think it would be very important  
13 to know if there is a valid and technically supported reason  
14 for the cross-sectional dimension of the plume in the  
15 saturated zone and also what basis is there for not  
16 considering uncertainty in that calculation. I can think of  
17 an obvious reason that it's not technical. But I think it  
18 would be important for the Board and the rest of us to find  
19 out if there is a valid technical basis for doing that in the  
20 TSPA, the viability assessment.

21 COHON: Okay, duly noted. Is there any point in  
22 revisiting this uncertainty issue with regard to that one  
23 parameter and what is really meant by that? Who is the one  
24 that introduced that? Is he still here? Maybe not. Abe, do  
25 you want to--

1           VAN LUIK: This is Van Luik, DOE. What the issue was is  
2 that for the Base-Case, in order not to convolute too many  
3 uncertainties, the saturated zone portion of the model is  
4 going to use basically the main calculation, the calibrated  
5 calculation from the site scale flow model and the sub-site  
6 scale flow model, and then in separate sensitivity analyses,  
7 which will be in the TSPA/VA documents, we will show what the  
8 affect would have been had we thrown in the uncertainties in  
9 those models. But for the Base-Case calculation, we were  
10 going to show basically the ones that Bill Arnold showed, and  
11 I think it's a call that we're making at this point to not  
12 convolute too many uncertainties on top of each other. But  
13 they will all be in there and you'll be able to find every  
14 one of those uncertainties.

15           COHON: Thank you. Did you want to say more about it,  
16 Steve? I don't mean to foment any kind of discussion here.

17           FRISHMAN: Well, I think you pretty well got your  
18 answer. It's a call and they don't want to confuse people by  
19 showing the uncertainty and ultimately the dose that they're  
20 going to produce in the executive summary of the TSPA. They  
21 won't give out a dose from the TSPA calculation. And sure,  
22 you can find all the rest in there, but the summary of it is  
23 going to be just--is going to be the base case and it's going  
24 to be extremely misleading because over the last day and a  
25 half, I have seen that uncertainty has not been reduced in

1 the unsaturated zone. In fact, it looks higher than I have  
2 seen it before in terms of the number of factors and getting  
3 down to an order of magnitude uncertainty here, another one  
4 here, stacking on each other. So we may end up with the  
5 Department very proudly announcing that at 20 kilometers we  
6 can meet what people might think is a reasonable dose  
7 standard, but not telling the people who are making decisions  
8 that that may have four orders of magnitude uncertainty  
9 attached to it.

10 COHON: Thanks for raising it. Yes, sir, please come  
11 forward, introduce yourself.

12 WILLIAMS: Yes, Dr. Cohon, I'm Mike Williams. You had  
13 called me earlier and at the time, I wasn't really prepared.  
14 I spoke yesterday concerning the containers with the two and  
15 a half inch I-beam on the shipping containers being faulty  
16 because of the welds. There was a couple more points I  
17 wanted to bring up that I would like someone to look into  
18 them if at all possible.

19 Evidently whoever was in charge at the time  
20 concerning these transportation containers at the test site,  
21 at the time, was using a material, now I do not know the  
22 technical name, but it's something similar to Kitty Litter  
23 they were putting in the bottom of these containers to absorb  
24 the liquid materials that would accumulate. Now, due to cost  
25 effectiveness, they changed it to a liner similar to the

1 materials you see in your butcher shops that soak up the  
2 blood in your steaks and so forth, which I understand are not  
3 quite as efficient as this Kitty Litter material. I don't  
4 know who made that decision or why it was made.

5           The other thing, these containers originally were  
6 wooden containers and they are being placed in open trenches  
7 with the idea of them deteriorating naturally, going into the  
8 soil. They've been replaced with metal containers which are  
9 leaking, and as far as I'm concerned, I don't understand the  
10 real importance of them leaking other than being on the  
11 highway, if they're going to be put in an open trench anyway.  
12 But I've been told that they're going to return to these  
13 wooden containers and if this is true, I would like to know  
14 why and why these things are being put in open trenches, this  
15 low-level material. It's in Area 5 at the test site.

16       COHON: Fair questions. Low-level waste is totally out  
17 of the purview of this Board and we have no knowledge,  
18 specific knowledge of these low-level waste depositions at  
19 the test site. However, is there anybody here from DOE who  
20 might know where to steer Mr. Williams to find answers to  
21 these questions?

22           (No response.)

23       COHON: We don't, but we'll be happy to try to find out  
24 for you. Right? Yes, we will find out and get back to you  
25 with a name and a contact.

1 WILLIAMS: Thank you.

2 COHON: Thank you. Is there anybody else who would like  
3 to comment or ask a question?

4 (No response.)

5 COHON: Well, thank you all for participating over the  
6 last day and a half, especially to all of our speakers and to  
7 the commenters.

8 We stand adjourned.

9 (Whereupon, at 6:00 p.m., the meeting was  
10 adjourned.)