

UNITED STATES  
NUCLEAR WASTE TECHNICAL REVIEW BOARD

FULL BOARD MEETING

October 15, 1992  
Plaza Suite Hotel  
Las Vegas, Nevada

BOARD MEMBERS PRESENT

Dr. John E. Cantlon, Chairman, NWTRB  
Dr. Patrick Domenico, Co-Chair, Morning Session  
Dr. Clarence Allen, Co-Chair, Afternoon Session  
Dr. Ellis Verink, Member  
Dr. Donald Langmuir, Member  
Dr. John J. McKetta, Member  
Dr. Edward Cording, Member  
Dr. Dennis Price, Member  
Dr. Garry Brewer, Member  
Dr. Warner North, Member

ALSO PRESENT

Dr. William Barnard, Executive Director, NWTRB  
Dennis Condie, Deputy Executive Director  
Dr. Leon Reiter, Senior Professional Staff  
Dr. Sherwood Chu, Senior Professional Staff  
Dr. Robert Luce, Senior Professional Staff  
Dr. Carl DiBella, Senior Professional Staff  
Russell K. McFarland, Senior Professional Staff  
Dr. Nava Garisto, Consultant  
Dr. Michael Apted, Consultant  
Ms. Paula Alford, Director, External Affairs  
Frank Randall, Assistant, External Affairs  
Ms. Vicki Reich, Librarian  
Ms. Helen Einersen, Executive Assistant  
Ms. Linda Hiatt, Management Assistant  
Ms. Nancy Derr, Director, Publications

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

2           DR. CANTLON: We'll convene the second day's session of  
3 the Nuclear Waste Technical Review Board. My name is John  
4 Cantlon. I chair the Board.

5           This morning's session will be a continuation of  
6 yesterday's session on the source term. The chair for this  
7 morning's session will be Dr. Domenico, and after lunch,  
8 where we switch to the Ghost Dance Fault, the session will be  
9 chaired by Dr. Clarence Allen.

10           So, Pat, it's all yours.

11          DR. DOMENICO: Good morning. I'm Pat Domenico. I'm co-  
12 chair of the Hydrogeology and Geochemistry Panel, and I've  
13 first a few announcements. There's a break scheduled for  
14 eleven-fifteen, which is three hours from now. We're going  
15 to change that. The break will be at 9:55.

16           The second announcement is again, today, they are  
17 having a buffet lunch for \$5.95 like they did yesterday.

18           A few years ago, or maybe not so long ago, maybe a  
19 year or so ago, the Performance Assessment Panel heard some  
20 presentations on transport modeling. Imbedded someplace in  
21 those discussions was a source term that we did not hear too  
22 much about at that time. Yesterday, we heard perhaps all we  
23 wanted to know, and perhaps even more about the details of a  
24 source term. Today, we will hear about which of those  
25 details are actually imbedded in the source term that will be

1 used in transport modeling.

2           So for lack of a better title, we might say that  
3 we're looking at today, in the practical sense, the source  
4 term in transport modeling for performance assessment.

5           So with that, we'll get started right away; first,  
6 by hearing from Bill O'Connell from triple L, dealing with  
7 combining processes, an engineered barrier system source  
8 term. Following Bill's presentation, we will have four  
9 presentations on the actual use of the source term by  
10 different groups.

11           Bill?

12         DR. O'CONNELL: Good morning. I'm Bill O'Connell from  
13 Lawrence Livermore National Laboratory. This morning we'll  
14 be looking at the source term from a different perspective,  
15 starting from the use of the source term and working  
16 backwards, or the input information that's needed for the  
17 source term, and the first three talks this morning are by  
18 DOE contractors, and these talks are correlated with each  
19 other.

20           Now, the first talk, my talk, will be how we pulled  
21 all these different pieces of information together to make a  
22 source term; the oxidation and dissolution of the spent fuel  
23 as you heard yesterday, and many of the other elements we  
24 heard yesterday; and also, the local hydrology and the  
25 container breach process, and the processes inside the waste

1 package, the hydrology and the transport. So pulling these  
2 together into a source term model will be the subject of my  
3 talk, and then the two following talks by DOE contractors  
4 will also talk about the source term model and its use in  
5 systems applications.

6           Now, expanding on the introduction, there have been  
7 two trains of calculations carried out in the Total Systems  
8 Performance Assessment-91 and this was presented to the Board  
9 in April of this year. So today, the source term, rather  
10 than the total system, will be the main focus of those, but  
11 there were two trains of calculations. They were coordinated  
12 so they were working with the same input space, but for  
13 slightly different purposes to cover the whole space or to do  
14 several detailed calculations within that input space.

15           At Livermore, we developed a simplified source term  
16 model based on our experience with our other source term  
17 models, and transferred the model to Sandia, and they used it  
18 in the Total Systems Performance Assessment.

19           Now, a few view graphs of the general survey of the  
20 field. First, a source term integrates over the performance  
21 of a large number of waste packages spread out over a large  
22 area, which may be a portion of the repository or the whole  
23 repository, so we have to look at the local conditions of all  
24 these different waste packages, what are the responses of the  
25 individual waste packages to those conditions, and then add

1 up those responses to get an area-wide release rate, which is  
2 the source term going into a total system transport analysis.

3           And particularly for Sandia's total system  
4 analyzer, which samples many times over a broad input space,  
5 we want a source term which is simple so that it can be  
6 iterated many times, and of course, we want it to have the  
7 major features of the process results, of the processes that  
8 are part of the engineered barrier system, and as a side  
9 feature, we want to avoid the minor features so that we don't  
10 get bogged down in details, and because of its application it  
11 should be good over a broad range of parameters, and it  
12 should use the total system parameters as inputs where  
13 appropriate; in particular, in the hydrology, the percolation  
14 flux downward through the mountain, and the saturated  
15 hydraulic conductivity of the matrix.

16           Now, this is using a conceptual model of Sinnock  
17 and others. It was published in the site characterization  
18 plan, whereby the downward percolation is carried by the  
19 matrix, and so if there is too much percolation, then the  
20 excess goes over into fracture flow and seepage flow. That's  
21 one possible conceptual model, and that's the one we'll be  
22 using in this source term.

23           Still looking at the big picture, the near-field  
24 environment is an influence on the engineered barrier system  
25 and on the transport through the near-field zone, and then

1 these different zones are also transport pathways, resistive  
2 transport pathways, and in the first application we didn't  
3 specifically consider the near field as a transport zone, so  
4 we sort of avoided the question of where to do the hand-over  
5 of the release rate, you know, from the engineered barrier  
6 system to the far field. It could be here or here, but we  
7 sort of avoided that problem, but we did include the near-  
8 field environment as an influence on the source term.

9           Now, doing the source term, we have to keep in mind  
10 that we have the full repository as a system, and at the  
11 heart of the repository we have individual waste packages,  
12 and the averaged hydrology goes into the local hydrology at  
13 the different waste packages, and there is a spatial  
14 variability to be expected, and one of the new features of  
15 this source term model is an explicit treatment of this  
16 spatial variability and hydrology.

17           Then we look at the individual waste package  
18 responses. The concepts in the individual waste package  
19 model would date back about two years to the Working Group 2  
20 joint effort in 1990, which was presented to a panel of the  
21 Board in 1991, but using those concepts, we get the releases  
22 from the individual waste packages, and then just sum them up  
23 to get the area-wide averaged release rate.

24           Now, the issues we have to keep in mind are, first,  
25 linking the processes on a broad scale and on an individual

1 waste package scale, and including localized variations about  
2 an area-wide average, and one thing we should keep in mind  
3 but did not in the first application was the correlations  
4 among the inputs and correlations of the outputs with the  
5 inputs. For example, the release rate might be higher in a  
6 local area if the hydraulic flow there is higher, and so the  
7 release rate and the transport capability are both correlated  
8 through the hydrology.

9           Now, looking at the individual waste packages at  
10 the heart of this EBS system, we started from the outputs,  
11 which is the release rate as a function of time from the  
12 waste packages, and worked backwards as to what do we have to  
13 know in order to calculate that release rate, and as in the  
14 1990 joint effort with U.C.-Berkeley and Pacific Northwest  
15 Laboratories, we decided to focus on these later processes in  
16 the sequence of events.

17           So the mobilization of the waste form from a solid  
18 to a soluble form, and the transport from the edge of the  
19 waste form into the host rock, of course, these processes  
20 depend on inputs from numerous fields; for example, the  
21 mobilization depends on waste form properties, the  
22 geochemistry and the hydrology, and the whole thing depends  
23 on having breach of the containers.

24           Now, these other processes we're taking as inputs  
25 right now, but in the future evolution of the model, we could

1 put process models instead of input structures. Now, the  
2 reason why we're being so simple in this approach is because  
3 even at the simple level, there are many alternatives which  
4 have to be considered.

5           The radionuclides, they are high solubility and low  
6 solubility. This affects the mechanism by which they're  
7 mobilized and released, and there are a few gases, and some  
8 of these are in two or three different locations within the  
9 spent fuel, and particularly important are the cladding  
10 surface and the fuel cladding gap where soluble elements  
11 could be mobilized quickly, and those in the spent fuel  
12 matrix, which can only be mobilized slowly, as the matrix is  
13 altered or dissolved.

14           In the initial model, we'll be looking at the high  
15 solubility elements in both locations, and the low solubility  
16 elements, which are mainly in the matrix, and the gas is not  
17 included in the initial model, but Sandia added a treatment  
18 of the gas before they went into their total system model.

19           Now, this concept of taking the broad average,  
20 individualizing it to the individual waste packages, and then  
21 adding it up again is shown in a data flow diagram format  
22 here. So the first sub-model is the local environment model,  
23 where we take the broad averages and find out what the local  
24 distribution consistent with those averages is, and then  
25 apply this local distribution to the waste packages, and it

1 turns out to be convenient to subdivide these waste packages  
2 into sets according to the type of water contact they have.  
3 Then calculate the release rates and sum them up, and finally  
4 get a release rate time history for any radionuclide over all  
5 the waste packages in an area.

6           Now, for the next segment I'll be talking about the  
7 local environment model that went into this. This is  
8 primarily a hydrology model, but I'll say a few words about  
9 the geochemistry at the end, in view of all the presentations  
10 that were made yesterday about geochemistry.

11           So we did treat the local variability of the  
12 hydrology by a few concepts and equations which I will get  
13 to. We treated variability in the rock mechanics in the  
14 sense that there is initially a gap--at least in the  
15 conceptual design--there is an air gap, and this gap may get  
16 filled over time through weathering or spalling from the  
17 borehole rock wall, and whether it does or not, that is an  
18 input parameter in this model, but at least it is considered,  
19 and the container breach times are considered as an input in  
20 the model.

21           Now, within a single waste package as well there is  
22 variability at different locations within the waste package.  
23 Only a fraction of the spent fuel is likely to be wet, given  
24 these low water flows and the partially-saturated conditions  
25 and high drainage possibilities.

1           The simplified model assumed that a fraction of the  
2 fuel was wet, but this fraction was consistent from one  
3 package to another. We didn't consider further variability.

4           Some specific features of the base case hydrology  
5 that were posed for this set of calculations by the total  
6 systems people and hydrologists; first, they had a  
7 distribution of percolation flux. This was based on  
8 alternate possible futures. It's one flux for the whole  
9 mountain, but it could depend on future climate, so there's a  
10 distribution. The average was about one or two millimeters  
11 per year, which is somewhat higher than we were considering  
12 as anticipated conditions, and that will have an influence on  
13 the waste package's response to this much of a groundwater  
14 flux.

15           Now, as the average flux increases, the local flux  
16 at the different packages will all increase, although there  
17 will still be differences from one package to another. More  
18 packages get wet, and they get more water.

19           Now, we wanted to have a response which varied  
20 smoothly, actually, as a function of the average infiltration  
21 flux. Different packages may have a sudden large transition  
22 from fairly dry conditions to fairly wet conditions, but  
23 different packages might see this response at different  
24 average infiltration levels, so we didn't want to treat all  
25 the waste packages the same and have an artificial big jump

1 in their response.

2           Now, how this works out for the local environments,  
3 for the waste package to have any water contact and,  
4 therefore, an aqueous release of radionuclides, it has to  
5 have some water contact. Either rubble could provide a  
6 pathway for diffusion, or seeping water could provide a  
7 mechanism for advective transport of radionuclides, and we  
8 assumed these two things were independent, and we assumed  
9 that the local percolation flux was lognormally distributed.

10           This concept was picked up from Duane Chestnut of  
11 Livermore, who published a paper in the International High-  
12 Level Waste Conference proceedings last April. He looked at  
13 Stripa data and some saturated hydrology conditions data, and  
14 found lognormal distributions of spatial variations in the  
15 flow under various conditions, so we picked up that concept  
16 to give some specific way of addressing what the  
17 variabilities are, and we assumed that, as I said earlier, if  
18 the total flow downward gets too high, then the excess goes  
19 into seepage through fractures, and that these are  
20 independent.

21           And the diffusion coefficient in the rubble zone  
22 depends on whether it's only moist conditions, or whether  
23 there is seepage over the surface of the rubble.

24           Now, this shows four different possible futures for  
25 the average percolation flux downward through the mountain,

1 ranging from small to high, and as you go toward the higher  
2 averages, we're assuming that the standard deviation is  
3 proportional to the mean, so the distribution gets broader,  
4 as well as going to higher values. We're talking about  
5 values on the order of 0.5 or 1 mm/yr of Darcy flux downward.

6           Now, the response at individual waste packages to  
7 such a flux is assumed to be what's shown here. As the total  
8 flux gets above this threshold for seepage, then the excess  
9 goes into seepage. So the seepage flow which can provide  
10 advective transport goes up linearly here, and we're assuming  
11 that the diffusion coefficient has a step change, just from,  
12 you know, it's higher when there is some seepage flow as  
13 well. This was a step change of one or one and a half orders  
14 of magnitude, actually.

15           So the output of the local hydrology model, we can  
16 calculate the fraction of waste package boreholes that have  
17 seepage flow as a function of the average flow, and an input  
18 that's passed through is the fraction where the walls have  
19 provided some rubble, and each of the waste packages has one  
20 of these four modes of water contact; either one or the  
21 other, or both.

22           Now, if there are both types of flow, then there  
23 are two parallel pathways away from the waste package, and we  
24 have to take that into account in the transport. Now, as far  
25 as geochemistry in the near field and impinging upon the

1 waste packages, we did not treat variability in this, but I  
2 have to say a few words.

3           Particularly within a waste package, the  
4 geochemistry will be dependent on the hydrology for the  
5 following reasons: Incoming with the groundwater are a  
6 certain amount of groundwater chemicals which control the  
7 chemistry, and then at the same time, part of the uranium  
8 surface is wet, and that is producing uranium into a  
9 chemically-reactive system, and if the uranium overpowers the  
10 incoming chemicals, then it's a uranium-controlled chemistry  
11 and we just have to keep track of its ratio; take the water  
12 influx per year times the concentration of calcium, and you  
13 take the fraction of surface of spent fuel which is wet, and  
14 an additional factor depending on how many grains down from  
15 the surface are wet, and the surface reaction rate.

16           Now, this particular interest in calcium arises  
17 from a calculation of Bruton and Shaw in 1987 that showed  
18 that for low amounts of uranium, the solubility is controlled  
19 by the solid phase of a calcium-uranium silicate, which  
20 precipitates out, and the recent work by Gray yesterday, the  
21 surface reaction rate of uranium in a flow-through system  
22 that separates this reaction rate from other things that  
23 could be going on in a low-flow system, so now we have at  
24 least some access to all the needed information and we can  
25 calculate this ratio.

1           And it does appear that the uranium does control  
2 the chemistry within the waste packages, so we have a low  
3 flow system in most of the waste packages; you know, low  
4 water to uranium ratio.

5           Now, getting back to the higher level of  
6 calculating the release rate from the various waste packages,  
7 we've organized the release rate according to the type of  
8 radionuclides and their locations, and then by these water  
9 contact modes. So there are many different cases, each of  
10 which has to be considered.

11           Now, for one radionuclide type and location, this  
12 data flow diagram shows the little expansion. The several  
13 arrows indicate the different water contact modes, and the  
14 release rate and time history is calculated for each water  
15 contact mode, and then the sum over a group of waste packages  
16 with similar properties is done in this part of the  
17 calculation, and the total sum is done here.

18           Now, expanding on this release rate calculation at  
19 the waste packages for a group of waste packages, the data  
20 flow diagram looks like this. Now we're getting down to a  
21 single waste package, or to a group of waste packages  
22 concerning breaches at different times, and we have to look  
23 at the waste form alteration. If a waste gets wet, then its  
24 alteration is spread out over considerable time, and if some  
25 waste is mobilized in a soluble form and it's release from a

1 single waste package is spread out over time, and these  
2 various time processes are coupled by a convolution over  
3 time, and the net result is a time history of the output.

4           Now we decided to treat this by looking at the  
5 parameters of a time history in a schematic way, and earlier  
6 work from 1990 and '91 show, that for the high solubility  
7 radionuclides, the release rate curves looked generally like  
8 this. They went up and they went down within a predictable  
9 time; sometimes in less than 10,000 years, or in the case  
10 where there's diffusion through a rubble zone with a large  
11 retardation, then this could last considerably over 10,000  
12 years. But at least we could see the end; we knew when it  
13 was going down.

14           Now, the low solubility radionuclides rise and  
15 reach a steady plateau, with a constant diffusion conditions  
16 or with a constant advective flow, then this release rate  
17 would be constant over a very long time period. So these are  
18 the characteristic curves. I showed two examples that are in  
19 the handouts from previous work which was presented in 1991  
20 to the panel on performance assessment.

21           Now here's releases from the highly soluble  
22 radionuclide, and for different water transport mechanisms,  
23 you still see releases go up and they go down, so we've  
24 decided to fit all of those shapes with this single  
25 standardized release rate shape that has a rise time and a

1 decline time, as well as a delay in starting.

2           Now, the most important parameter is the decline  
3 time, which is the longest time constant in the curve, and  
4 which pretty much determines what the peak release rate is.  
5 And in case you're interested in the breakthrough in the  
6 early parts of the curve, then the rise time and delay time  
7 are secondary parameters of this curve, and we did a similar  
8 standardized shape for the solubility limited radionuclides.

9           But getting back to the high solubility  
10 radionuclides, and the three processes that were involved in  
11 time, there was the container breaches, which depend on the  
12 time spread in re-wetting of the containers after a hot  
13 period, and the time spread in breaches after becoming wet,  
14 and we used the one parameter model for the breach rate of  
15 the waste packages given that they had become wet.

16           In the waste form alteration, we assumed that the  
17 alteration was proportional to the amount remaining. In  
18 previous work, we assumed a constant value until it was all  
19 gone, but with the first order, any shape is about equivalent  
20 as long as it has the right properties over a reasonable  
21 period of time.

22           And transport. In the flow-through case, the  
23 transport goes rather quickly, and in diffusion it would be a  
24 much longer spread over time. And we can calculate these  
25 curves by taking the longest time constant in each and doing

1 a square root of the sum of the squares to get a time  
2 constant of the output. So that's an approximate treatment,  
3 but it does capture the primary features.

4           Now, the main parameters which are important--and,  
5 of course, all of them are uncertain at this time, but the  
6 important uncertain parameters, I just listed a large number  
7 of them in the--and look at the handout for the details, but  
8 in total system hydrology, there are several parameters. In  
9 the waste package hydrology, there's the fraction of the  
10 local flux which actually gets into the waste package, and  
11 the fraction of the fuel surface wetted.

12           In rock mechanics, the influence is the fraction of  
13 boreholes with rubble and how much of the waste package is  
14 contacted by that rubble, and there are some parameters for  
15 diffusion.

16           And in geochemistry, waste form interaction,  
17 that's, of course, very important and we only handled that by  
18 input parameters, but the fuel matrix alteration rate, we  
19 were taking a maximum rate over a range of temperatures and  
20 conditions, and element solubilities, a maximum over a range  
21 of conditions. So this really sums up the things which were  
22 presented yesterday. We were taking maximum values, and this  
23 does not work very well. We will have to have a reiteration  
24 and get more detail into the model, because by taking  
25 maximums and simple bounding values on the chemistry and on

1 the hydrology, this is over-predicting the releases; and the  
2 container parameters as well are important.

3           Now, looking ahead to the interplay of the source  
4 term model with the total system model, for the next  
5 iteration, we would want to consider whether there are trends  
6 in these downward percolation fluxes across the repository,  
7 or trends in the chemistry, because there is a correlation of  
8 the water flux on an area-wide basis, and the source term on  
9 that same area-wide basis, and because the repository is fit  
10 into one bed of tuff--which is at about a 10 degree slope--  
11 there are differences in the distance to the water table and  
12 in the number of rock layers, so, therefore, in the transport  
13 time. So there's some correlation through the hydrology in  
14 both source term and total system performance.

15           But summarizing what we learned from the first  
16 simplified model, with the assumptions that I described  
17 before and the results that are at low, say at a low  
18 distribution of downward percolation flux, you might have  
19 just a few per cent of the waste packages with a seepage  
20 flux, but those few per cent will contribute most of the  
21 source term because of the higher diffusion when there's  
22 seepage present, and because of the advective flux with the  
23 seepage. So a few per cent can contribute most of the source  
24 term.

25           However, in the total system problem that was posed

1 in the last exercise, the average percolation flux was fairly  
2 high, so I think more than 50 per cent of the waste packages  
3 had percolation flux, and there was a fairly high release  
4 rate calculated because of those assumptions.

5           We can see qualitatively that there are  
6 correlations induced by the hydrology among the container  
7 performance, the release rate, and the total system transport  
8 performance; and similarly, if we go to a fracture-flow model  
9 such as Buscheck and Nitao's, temporally transient and  
10 spatially distributed flux down through fractures, non-  
11 equilibrium flow, then we could have a set of flows in  
12 fractures and this would again be distributed over space, and  
13 most of the fractures would not be carrying any flow, because  
14 you are limited by the total influx constraint, and would  
15 have similar results as we found even in the matrix fracture  
16 interplay model, that a few waste packages would have a  
17 substantially high release. So a small fraction of the waste  
18 packages would control the whole release.

19           So in summary, this model does consider the spatial  
20 distribution in an explicit form, and it's based on concrete  
21 ideas backed up by data which was published within the last  
22 year, and as far as chemistry, we would like to include that  
23 in the next iteration and we're looking, at least, for some  
24 handle, some concrete ideas to make it more than just a "what  
25 if" approach. So as ideas come above the threshold level

1 from these various detailed studies, we can incorporate them  
2 into the total system model.

3           Thank you.

4       DR. DOMENICO: Thank you, Bill.

5           Any questions from the Panel; Warner?

6       DR. NORTH: Warner North.

7           Could you describe to us the state to which this  
8 has been implemented; in other words, how far have you gone  
9 from essentially a conceptual description of this, to  
10 implementing it with numbers and carrying out sensitivity  
11 analysis? You gave us a set of qualitative insights, and I'm  
12 not really sure what backs those up. And then, what's the  
13 state of the documentation of it?

14       DR. O'CONNELL: Well, this model, you know, I was saying  
15 this year we did this and we did not do this, and within  
16 those limitations, that conceptual model and specification  
17 were transferred to Sandia. They did implement it in their  
18 total system analyzer code, so it has been used. You'll see  
19 some results when Mike Wilson makes his presentation.

20       DR. NORTH: Okay.

21       DR. O'CONNELL: We did not do any sensitivity study  
22 using the full computer code. The sensitivity considerations  
23 I alluded to were just derived from the equations, or looking  
24 at the conceptual model, but it's easy to do a sensitivity  
25 analysis on part of the problem. When adding up all the

1 different components of the problem, then we really would  
2 need to use the computer code and do a formal sensitivity  
3 analysis that has not been done yet.

4           This model is documented in Sandia's report on  
5 their total system calculation. I have the report which  
6 documents the rationale for it that's in progress. It's  
7 limited by budget and priorities.

8       DR. NORTH: So the short summary is the documentation  
9 that exists is in the Sandia report?

10       DR. O'CONNELL: Yes. It does describe the equations and  
11 assumptions.

12       DR. NORTH: What strikes me as interesting is I don't  
13 recall quite as much focus on the spatial variability issues  
14 in that report as in what you've presented, and I would be  
15 interested in seeing a little bit more in that area.

16       DR. DOMENICO: Any other questions from the Panel  
17 members?

18       DR. LANGMUIR: Don Langmuir.

19           Overhead 17, I was encouraged by the wording at the  
20 top, which said, "Geochemistry variation is a fertile field."  
21 What I was interested in, in particular, was your finding  
22 that calcium-uranium silicates, where the basis for selecting  
23 a source term for uranium was to use that mineral set as the  
24 source term rather than the oxide field itself, and it  
25 occurred to me--pardon me?

1 DR. O'CONNELL: No, the oxide field was used as the  
2 basis for the source term. The calcium-uranium silicate  
3 would be used as the basis for determining the solubility of  
4 the uranium only, but the--in principle, the source term  
5 could be--I mean, the matrix could be altering and then re-  
6 precipitating in this other form, so you have a churning  
7 going on, which gives you a non-uniform release of some other  
8 elements.

9 DR. LANGMUIR: Yeah. The only point I wanted to make  
10 was that this is a very tricky business in the sense that  
11 whether those solids are there at all will be a function of  
12 the water content that you assume present at the time of a  
13 breach. So at very low water contents, you're going to get  
14 highly-soluble phases produced, which then could be secondary  
15 source terms. At very high water contents, you're going to  
16 have less soluble phases perhaps controlling the releases,  
17 and so you have to be flexible on what you pick for your  
18 phases that control the releases away from the waste and make  
19 it a function of the water content you assume. It's a very  
20 tricky moving target.

21 DR. O'CONNELL: You mean, as a function of the water  
22 chemistry or of the--

23 DR. LANGMUIR: Well, the water content itself will  
24 define whether a highly soluble phase even exists.

25 DR. O'CONNELL: Yeah. I agree it's a--there is a lot of

1 details that have to be pinned down before you really know  
2 the geochemistry. The calculation I referred to was a  
3 scoping calculation, using J-13 water, or concentrated J-13  
4 in water as the assumed incoming water, and then gradually  
5 titrating more uranium into it over time, and the time axis  
6 was reaction progress rather than actual calendar time. And  
7 now with the surface reaction rate, we can convert that into  
8 a calendar time. But there are many factors that would have  
9 to be checked.

10 DR. DOMENICO: Any more questions?

11 DR. APTED: Bill, we've seen yesterday some, oh, some  
12 proposed alternate designs. I don't how the terminology goes  
13 within the project. I don't want to misname them, but  
14 obviously there is some consideration of different  
15 emplacements from the SCP-type emplacement.

16 Could you comment on the applicability of these  
17 models--and maybe the subsequent speakers can address the  
18 same issue--to handle these, you know, if an alternate design  
19 is proposed for the tunnel emplacement, are we still in good  
20 shape with applying these same models?

21 DR. O'CONNELL: Yes. We have a suite of models, and  
22 recently we have been doing some work in collaboration with  
23 Babcock and Wilcox on looking at the performance  
24 considerations for alternate designs, such as some of these  
25 in drift designs. So we have been doing sensitivity analysis

1 there in relation to design rather than total systems, and we  
2 have a diffusion model which can handle the emplacements with  
3 a backfill rather than an air gap, and we have an advective  
4 model which can handle the seepage flow, and whether the air  
5 gap is an effective barrier. So we have a suite of models  
6 and we hope to combine them into one grand model in the  
7 future.

8 DR. DOMENICO: Any other questions from the Board?

9 I have one easy one, I think. The advective flux  
10 is merely a carrier here. What controls, in your source  
11 term, what controls the rate at which these materials enter  
12 into that carrier? Is it strictly solubility controlled, or  
13 what are the details?

14 DR. O'CONNELL: For low solubility elements, it is their  
15 solubility which controls their rate of entering this  
16 advective flux. For high solubility elements, it is the  
17 matrix alteration rate, the uranium oxide fuel pellet matrix  
18 which controls. Now, we're assuming that this matrix alters  
19 and part of it can re-precipitate either as a secondary phase  
20 with calcium, or a secondary phase with a different oxidation  
21 state of uranium, so that there is a forward progress of the  
22 uranium oxide surface alteration even under these low flow  
23 conditions.

24 Now, there may be some limiting factors which would  
25 bring this progress to a halt, but we are not including that

1 in the model. I think that's an interpretive approach.

2 DR. DOMENICO: So this is merely--it's rate controlled.  
3 It's reaction to actual surface. Where did that information  
4 come from on that?

5 DR. O'CONNELL: We took our rate from Chuck Wilson's  
6 experiments, where he was looking at the release of cesium,  
7 iodine, and so forth as an indicator of the overall reaction  
8 progress. Now, this may combine grain boundary release as  
9 well as matrix release, but we took that as a bulk indicator  
10 of what fraction of the uranium oxide fuel pellet mass in its  
11 cracked and fragmented form could be released per year when  
12 it's contacted; in fact, when it's immersed in water.

13 Now, the other experiments--for instance, by Walt  
14 Gray--on flow-through tests would give other surface reaction  
15 rates, and I think he said they may be a factor of ten lower,  
16 and if you consider a low flow system with solubility or  
17 secondary precipitants, you know, you may go up or down on  
18 the order of magnitude, so that becomes more complicated.

19 DR. DOMENICO: Are those complications imbedded in your  
20 term?

21 DR. O'CONNELL: No. We took our results from, as I  
22 said, this one series of experiments, sort of a static  
23 reaction progress experiments dissolving various elements,  
24 and those static tests do incorporate a number of processes  
25 going on, but other conditions could give you other processes

1 and other net rates.

2 DR. DOMENICO: And then the last thing, do I understand  
3 that this is the source term used in the Sandia model? This  
4 is what you developed here?

5 DR. O'CONNELL: Yes.

6 DR. DOMENICO: Any questions from the staff?

7 (No audible response.)

8 DR. DOMENICO: Perhaps we have time for one from you  
9 people out there.

10 MR. MCGUIRE: Robin McGuire with Risk Engineering.

11 In this uncertainty characterization of the  
12 infiltration rate which is, as you say, a lognormal  
13 distribution assumed, are you assuming, effectively, that  
14 that distribution represents the range of flows, of  
15 continuous flows from just under the subsurface to the  
16 saturated zone?

17 DR. O'CONNELL: We're considering the percolation flux  
18 which gets, say, below the root zone and percolates all the  
19 way down toward the water table, and we're assuming that in  
20 the repository horizon, in that type of rock, that the  
21 spatial distribution is as I have described. Now, it's  
22 lognormal. We have no idea what the variance should be, so  
23 that's an open information issue. It could be different at  
24 different horizons, but it's the same total flux. It could  
25 be a different variability.

1 MR. MCGUIRE: But you're assuming that if at some point  
2 in the repository it is at the mean +2  $\sigma$  level, you're  
3 assuming that that mean +2  $\sigma$  flux is continuous down to the  
4 saturated zone; is that right?

5 DR. O'CONNELL: No, there could be mixing, say, if you  
6 have more concentrated flows in certain local areas, these  
7 could mix together at the next layer below the repository  
8 horizon. So we're not making any assumptions on whether that  
9 happens or not.

10 MR. MCGUIRE: You're not making any assumptions? Okay.  
11 All right.

12 DR. DOMENICO: We're going to have to go forward now.  
13 Thank you, Bill.

14 We're now going to hear about the Sandia model  
15 source term. Actually, we have two presenters here and the  
16 first one will be Mike Wilson, giving us some information on  
17 the source term for SNL total performance assessment.

18 DR. WILSON: All right. I'm going to follow up Bill's  
19 discussion with some of the application of the source model  
20 in our total system performance assessment, and discuss the  
21 results a little bit and some of the things that we want to  
22 do in the next iteration of the total system performance  
23 assessment, and then Rallie is going to follow--Rallie  
24 Barnard is going to follow with some other aspects of the  
25 source term.

1           One thing I want to emphasize is that we're talking  
2 about a source term for total system performance assessment,  
3 which has rather different needs than the source term that  
4 would be used for the more specific EBS performance  
5 assessment, and Bill has already alluded to some of this; the  
6 fact that we need to couple the source term into flow and  
7 transport calculation going onto the accessible environment,  
8 and the fact that the EPA requirements force us to do  
9 probabilistic calculations, whereby we need to calculate a  
10 lot of realizations, make us want to keep our source term  
11 relatively simple compared to the kinds of source terms that  
12 they used in the EBS performance assessment.

13           So the trick there is to make it simple so that it  
14 doesn't take too much computer time and that we can still  
15 understand it, and yet, somehow retain what's important.

16           I'm going to just talk about the areas where we  
17 expanded or added a little bit to what Bill has already  
18 talked about. First of all, let me mention that we didn't  
19 include all the possible radionuclides in our calculations.  
20 There is a set of ten that we used in the calculations where  
21 the source term was coupled to transport calculations. In  
22 some of the other calculations, the human intrusion and  
23 volcanism calculations, where the releases were direct to the  
24 surface without any transport calculation, then we included a  
25 much larger group of nuclides.

1           But for the transport calculations, we included the  
2 ones that are highly mobile that we expect most of the  
3 releases to be from and, in addition, we included a few of  
4 the high inventory actinides, so we think we have a  
5 representative set of nuclides that should encompass most of  
6 what we expect to be released.

7           As Bill talked about just a minute ago, the basic  
8 releases in the source model are divided into two classes;  
9 the alteration-limited and the solubility-limited, and they  
10 have different shapes for the release rate curves, and we  
11 picked five of each for our calculations, and the model is  
12 strictly for spent fuel at this point. We didn't do any  
13 modeling of glass waste, and in coming up with the inventory  
14 for it, we simply took a mix of 60 per cent PWR and 40 per  
15 cent BWR fuel, with some specified typical burnup.

16           Now, as you may recall from the presentations we  
17 made to the Board last April on our total system performance  
18 assessment, we included two different models of how the water  
19 flow takes place in Yucca Mountain in the unsaturated zones;  
20 one, the composite porosity model assumes kind of a  
21 widespread flow pattern with the matrix and fracture flows  
22 tightly coupled, and that is the model that Bill was assuming  
23 when he developed his source term. And so the source term  
24 applied to the composite porosity flow calculations is  
25 exactly what Bill already described.

1           The other water flow model was what we call the  
2 Weeps model, which is an episodic fracture flow dominated  
3 model, and we had to make a few alterations to the source  
4 model to fit it into this framework. First of all, Bill  
5 talked about how he calculated the number of wet containers  
6 and the number of containers that were only moist based on  
7 the hydrology inputs. Now, the whole basis of the Weeps  
8 model is a calculation of how many of the waste containers  
9 are contacted by water from flowing fractures, so we replaced  
10 that part of the source model with a different algorithm for  
11 calculating how many are wet.

12           And then these other two are simple approximations  
13 that we thought kind of fitted into the philosophy of our  
14 Weeps model. We only had releases from the wet containers,  
15 so that the moist ones were not contacted by any dripping  
16 water, and so the assumption was that they simply did not  
17 fail, at least within 10,000 years. And we included only  
18 advective releases from the flowing water in the fractures,  
19 and not diffusive releases for this. These two would be easy  
20 to modify, but I don't think they would affect the results  
21 significantly. This change in the algorithm for calculating  
22 how many are moist and wet does make a big difference.

23           We also wanted to calculate gaseous release and  
24 transport, and the source model that Bill developed was  
25 intended for aqueous releases, so we had to kind of make do

1 with it as best we could given the amount of time that was  
2 available.

3           First of all, this I don't think is really an  
4 approximation. Carbon-14 is the only nuclide that we think  
5 is going to have significant gaseous transport. I don't know  
6 that anyone's done an exhaustive study on that, but that  
7 seems to be a fairly general consensus, and the primary form  
8 of it should be in carbon dioxide.

9           Now, the source model that we used didn't have any  
10 provision for cladding failure or anything like that. The  
11 interior of the containers is basically just one black box,  
12 and so the quick release part of the Carbon-14 from the  
13 surface of the cladding was lumped together with the quick  
14 release part from within the fuel rods, the gap and grain  
15 boundary parts, as one prompt release fraction, and that's a  
16 pretty typical thing for people to do anyway.

17           The releases, or possible releases from fuel  
18 assembly hardware and from the inside of the cladding--I  
19 mean, the matrix or the cladding, if you will--was not  
20 included in the source model. My feeling is that the  
21 releases from the fuel assembly hardware might be  
22 significant, but I don't know. So that's one place where  
23 we're not really completely conservative, and the 40 per cent  
24 there is the--what we included was the Carbon-14 in the fuel  
25 pellets and in the little layer that's on the outside of the

1 cladding, and that amounts to a little over .6 of a Curie per  
2 metric ton, and that is 40 per cent of the old Carbon-14  
3 inventory of one and a half Curies per metric ton.

4           Now, as Rich Van Konynenburg talked about  
5 yesterday, he's done some work on revising the estimates of  
6 the Carbon-14 inventory, and he revised it downward to one  
7 Curie per metric ton, and if you go by that, then we are  
8 including 60 per cent of the inventory.

9           We didn't do any kind of calculation of how the  
10 Carbon-14 gets out of the waste container. We assumed that  
11 as soon as it's mobilized, that it's released.

12           Okay, so let me talk about the results a little  
13 bit, and this is going to take a little bit of explaining.  
14 This bottom one is something that I think people are used to  
15 seeing. This shows our final results of the CCDF of the  
16 releases to the--cumulative releases to the accessible  
17 environment over 10,000 years compared to the EPA limits, and  
18 the two curves here are for the two different water flow  
19 models.

20           The top one is something that is probably a little  
21 foreign to people. It is a probability distribution of the  
22 peak release rate from the EBS compared to the NRC release  
23 rate criterion of  $10^{-5}$  per year, and what this is showing us,  
24 then, is that for the Weeps calculation, something like 7 or  
25 8 per cent of the time, the NRC criterion was exceeded, and

1 for the composite porosity calculation, 100 per cent of the  
2 time it was exceeded.

3           Now, I'm not presenting this to tell you that I  
4 think that the release rates from the EBS are high or  
5 anything like that. This is intended to put our source model  
6 into perspective and show you that the releases from the  
7 source model, as we applied it, and with the input parameters  
8 that we used, are very high. And so that's something  
9 important to keep in mind.

10           However, it turned out that the travel times to the  
11 accessible environment were long enough that it compensated  
12 for those high release rates, and the final values are still  
13 well below the EPA limits.

14           In the gaseous releases, the story is similar, is  
15 very similar for the release rates compared to the NRC limit.  
16 These curves look pretty much just like the curves you saw,  
17 and that's because we didn't have, as I already said, we  
18 didn't have a lot of special things in the source model for  
19 handling Carbon-14. The source model for Carbon-14 is just  
20 about the same as the source model for technetium, with the  
21 different inventory and different prompt fraction, but the  
22 story is pretty much the same.

23           Now, the story for the releases to the accessible  
24 environment is rather different because, in this case, the  
25 gaseous travel times are not long enough to compensate for

1 the high release rates, and so there's two things to keep in  
2 mind about this:

3           Number one, I strongly believe that this is a very  
4 conservative source model, and if we--as we hope to do--go  
5 into some of the parts of the model that are the most  
6 conservative and try to come up with more realistic versions  
7 of them, to move these curves over, then it's going to move  
8 these curves over as well; and secondly, the way we did the  
9 Carbon-14 transport calculation is also probably pretty  
10 conservative, and we're going to try to refine that somewhat,  
11 also.

12           All right. Now let me go on to some of the things  
13 that we hope to do in our next performance assessment  
14 iteration. As you know, we've been committed to iterating  
15 these total system performance assessments every one and a  
16 half to two years, and so these are some of the ideas we have  
17 for directions we want to go for the next iteration, and  
18 chances are, we're not going to be able to do all the things  
19 on this list. It's going to depend on how many people are  
20 available and how much time is available and how much money  
21 is available and all those kinds of things, but these are  
22 some of the things that we know are important and need to be  
23 looked at, if not in this iteration, then in the next one.

24           The first two are things that seem to be on  
25 everybody's mind these days. We really want to look at the

1 performance of some of the new container and emplacement  
2 designs and thermal loadings that everyone is interested in  
3 right now. We think that people are really, really  
4 interested in seeing how these things stack up as far as  
5 their total system performance.

6           We want to look at, take another look at the  
7 radionuclides that we included in the calculations and see if  
8 we can think of other ones that may be important and need to  
9 be included, and that's something that is somewhat scenario-  
10 dependent, you know. Depending on the kinds of processes and  
11 events that you have going on in any given calculation, you  
12 may need to revise the list of nuclides you include in the  
13 calculation.

14           We need to include models for releases of Carbon-14  
15 from the cladding and from the fuel assembly hardware, or  
16 else show that they're not significant.

17           We need to come up with a model for releases from  
18 the waste glass. We would like to look at the performance  
19 implications of colloid formation and transport. One really  
20 key aspect of the source model we have is the matrix  
21 alteration assumption or hypothesis, whatever you want to  
22 call it, and based on the kinds of things that Bob Einziger  
23 and Walter Gray presented yesterday, one thing that's likely  
24 is that that matrix alteration is highly temperature-  
25 dependent, and so this fits in with what I said before about

1 looking at the variations in thermal loading, and in order to  
2 be able to look at variations in thermal loading, we're going  
3 to have to put in some of these temperature dependencies like  
4 that, and I probably should have listed this one next. Other  
5 temperature dependencies may be important as well. We may  
6 need to put in something about how the solubility varies with  
7 temperature and how container failure varies with  
8 temperature, for example, but we're limited in how much  
9 information we have on some of those things.

10           Another thing that is important is the coupling  
11 between the source term and what's going on in the far field.  
12 In the current source model, there are three of the source  
13 model parameters that are coupled with the far-field  
14 hydrology, and that's the number of containers that are in  
15 wet conditions, and the amount of flux that those containers  
16 see, and the affected diffusion coefficient depending on  
17 whether it's moist or wet. We would like to include  
18 additional variables, you know, strengthen the coupling.

19           One obvious example is container failure. You  
20 would expect that containers in wet conditions probably fail  
21 quite a bit quicker than containers that are in only moist  
22 conditions.

23           If possible, I would like to see us include the  
24 container and cladding as barriers to the transport out of  
25 the waste package. That's a difficult thing to do and hard

1 to justify, and so I don't know if we will get very far with  
2 that.

3           Many of the source parameters in our calculation  
4 for this TSPA were just taken as constants for convenience,  
5 and we need to develop distributions for them. One simple  
6 example is the fraction of the containers that have rubble  
7 infill in their boreholes. We just said that to be 50 per  
8 cent for these calculations, but it would be a simple matter  
9 to use a distribution. It's not as simple a matter to come  
10 up with some sort of justification for the distribution that  
11 you use, which is why we didn't do it the first time, and  
12 there's many other kinds of cross-correlations that you can  
13 imagine that could be important, and we would like to look  
14 into that.

15           To sum up, the source model that we used for these  
16 calculations, I think, is a real good start, but it's  
17 probably too conservative, and in the future calculations  
18 we'd like to work on relaxing some of the conservatism, and  
19 also, to look at some of the new design options that people  
20 are interested in these days.

21       DR. DOMENICO: Thank you much, Mike.

22           Any questions from the Panel; Don?

23       DR. LANGMUIR: Don Langmuir; Board.

24           Mike, in light of the new energy bill, C-14 may be  
25 a moot point, but does your model consider retardation or

1 retention of C-14 as CO<sub>2</sub> in the carbonate systems? It should  
2 do that.

3 DR. WILSON: Yes.

4 DR. LANGMUIR: As it goes up through the far field, that  
5 is part of your model?

6 DR. WILSON: Yes.

7 DR. LANGMUIR: How have you quantified it?

8 DR. WILSON: Whether we've included as much retardation  
9 as there should be is uncertain. We have a coupling between  
10 the carbon dioxide and the carbonate, or bicarbonate in the  
11 water. We don't have any coupling with the solid, and that's  
12 something that could increase that retardation that we have  
13 not included yet, and it's also something that's temperature-  
14 dependent, and we haven't got the full temperature-dependence  
15 in the transport calculation, either.

16 DR. DOMENICO: Yes, John?

17 DR. CANTLON: Cantlon; Board.

18 You indicate that in your next--some of your future  
19 iterations you're going to look at the glass wastes, and also  
20 look at colloid formation in transport. Are there any data  
21 that would suggest colloid from the glass wastes might  
22 enhance mobility of the spent fuel?

23 DR. WILSON: I don't know enough about it to be able to  
24 answer that. I think that there certainly is evidence that  
25 the glass forms colloids as it breaks down, but I don't know

1 enough to really address the subject.

2 DR. DOMENICO: Any other questions from--yes, Nava?

3 DR. GARISTO: Nava Garisto.

4 I didn't understand your boundary conditions. For  
5 example, at the source, you were saying that the  
6 radionuclides--the technetium, selenium and others--were  
7 released based only--limited by alteration of the matrix?

8 DR. WILSON: Um-hum.

9 DR. GARISTO: I don't understand why this should be  
10 valid.

11 DR. WILSON: Well, I should probably let Bill answer  
12 that since it's his source model, but I'll try. The idea is,  
13 as I understand it, is that as the  $UO_2$  oxidizes to the  $U_3O_8$   
14 state, that the technetium and iodine and carbon and those  
15 things are freed up for transport.

16 DR. GARISTO: This seems to be inconsistent with the  
17 presentations yesterday that showed that these kinds of  
18 radionuclides are released from gap and grain boundary and  
19 their releases are not really dependent on the dissolution of  
20 the matrix.

21 DR. WILSON: We're including the gap and grain boundary  
22 part as a separate thing, but the question is whether the  
23 releases from the fuel matrix are important. If we only have  
24 releases from the gap and grain boundaries, then the releases  
25 are comfortably low and we're safe, but we feel like, to be

1 conservative, we need to consider the case of what if there  
2 is a significant amount of release from the matrix or the  
3 fuel pellets. Without that, we have very little trouble in  
4 meeting the standards.

5 DR. GARISTO: And what boundary condition did you use at  
6 the exit?

7 DR. WILSON: For the advective ones, there is no really  
8 boundary condition. You just have some amount of water  
9 flowing through and it is saturated with the nuclides--or  
10 it's probably not saturated in the case of the technetium  
11 because it's rate-limited, and then it carries it out.

12 For the diffusion calculation, they set the  
13 concentration to zero right at the borehole walls, and  
14 calculated the diffusion across a 3 cm gap.

15 DR. DOMENICO: We're going to hold further questions and  
16 let the other part of the Sandia team speak, and then maybe  
17 we can open it up to the first three presenters.

18 Rallie Barnard?

19 DR. BARNARD: I'm going to talk about an aspect of the  
20 total system performance assessment analysis that was not  
21 discussed at all in the April meeting for the Board, nor is  
22 it contained in very much detail in the TSPA document.

23 And what that is, is to look at one sensitivity  
24 study done on the source term; and specifically, it was done  
25 on the human intrusion analysis which used both the standard

1 source term, as you've heard about previously, and what I  
2 call a detailed one, which contains more information. All  
3 the remaining analyses of the TSPA-91 use a standard source  
4 term.

5           Well, what is the detailed source term? I think we  
6 can all agree that there are a great number of uncertainties  
7 about the source term, but one of them that we can look at  
8 fairly easily is to ask whether the standard source term  
9 glosses over some of the differences in the radionuclide  
10 inventory which could arise because of a difference in the  
11 reactor types of the fuel that we're looking at, the degree  
12 of burnup of the fuel, and the decay of the fuel since its  
13 discharge from the reactor.

14           Well, the standard source term that was used was  
15 taken from the SCP, but abstracted--to use our favorite word  
16 for TSPA-91--to make it more computationally easy to use, I  
17 guess. The detailed source term was taken from the  
18 characteristics data base. That's a document and a project  
19 done primarily by the folks at Oak Ridge, which is to  
20 characterize the exact nature of all the spent fuel being  
21 discharged from commercial reactors since the start of time.

22           The standard source term, as we used it--and as you  
23 have heard before--is 60 per cent spent PWR fuel, 40 per cent  
24 BWR, where the burnups used for the PWR and BWR are as  
25 follows here. Furthermore, ten years was used as the decay

1 time for the fuel. If you stop and think about that, based  
2 on the current schedule of the repository, that's a fairly  
3 short amount of decay which has occurred.

4           Now for the detailed source term, what I did was to  
5 look specifically at both PWR and BWR spent fuel inventories  
6 as a function of burnup and decay, and develop the detailed  
7 source term. You've seen this picture before in a number of  
8 incarnations, but this is my 3-D color version of it, and  
9 what it shows is the discharge year starting in 1970--this is  
10 for PWR. This is the first date for which there are data in  
11 the characteristics data base--going out to the year 2040,  
12 which is the projected end of the data base. There are no  
13 further projections for discharges of fuel.

14           It plots, also, the burnup given here in megawatt  
15 days per metric ton of uranium, and so you can see that there  
16 is a great range of burnups and decays, peaking at roughly  
17 40,000 megawatt days in about 1990--some odd.

18           The detailed source term was not a general purpose  
19 source term. It was somewhat specific in its application,  
20 because it was designed to only be used for looking at the  
21 consequence of disruptive events; and specifically, I used it  
22 for the human intrusion drilling scenario. Some of the  
23 assumptions that I made were that the repository was going to  
24 be active until roughly 2040, which happened to coincide with  
25 the end date of the characteristics data base, and that the

1 repository would be loaded with the oldest fuel first, and  
2 the reason that this is for disruptive events only is because  
3 it was assumed that the repository would be closed and  
4 everybody would have gone home before the disruptive events  
5 would start. It's quite unlikely that people would be on top  
6 of the mountain drilling while other folks were down inside  
7 working on the mountain.

8           So the point of this is that the most sensitive  
9 measure of the source term would be to actually look at  
10 differences in inventory, and a disruptive event such as  
11 human intrusion drilling which directly brings material to  
12 the surface without any filtering process in the way of  
13 aqueous or other transport will be a sensitive measure of the  
14 differences in the two inventories.

15           So in order to be able to make this computationally  
16 usable, I grouped the inventories as shown on the previous  
17 slides for the PWR inventory as a function of burnup and  
18 decay into ten-year increments, and then I calculated the  
19 weighted average burnup for each of these decay groups, and  
20 figured out if people started loading the repository from  
21 oldest fuel to newest fuel, what proportion of it would be  
22 PWR and what proportion would be BWR, what would be the  
23 burnups for those, and what would be the proportion of the  
24 entire repository for those groups.

25           Well, the results are that there is very little

1 difference between the base case, which is the blue line  
2 here. This is the CCDF showing the cumulative release to the  
3 accessible environment, similar to what Mike showed  
4 previously. There is very little difference between the  
5 results for the base case in blue and the detailed source  
6 term in green.

7           The reason for this is that the repository  
8 inventory for the detailed source term breaks down into  
9 roughly 25 per cent apiece for fuel which is 30-years-old,  
10 40-years-old, and 50-years-old, and with burnups of about  
11 somewhat higher than any value in the standard source term,  
12 but in order to get a significant difference--which is the  
13 most significant is seen down at the lowest probability--you  
14 have to have a confluence of unlikely events, such as hitting  
15 a very low or a very high burnup source term--or inventory--  
16 and doing it early in the game or late in the drilling--in  
17 the repository life cycle, and those are unlikely occurring  
18 events. Otherwise, it appears that the results are  
19 substantially the same.

20           Well, that's for the overall picture for all the  
21 releases. If we look at the three or four radionuclides  
22 which contribute the most to direct releases, we see  
23 plutonium, americium--<sup>240</sup>Pu and <sup>239</sup>Pu, and <sup>241</sup>Am roughly  
24 contributing in the 30 per cent range, and cesium next.

25           If we look at some of those individually, here's

1 what you see if you look at the actual inventory of  
2 Plutonium-239 as a function of burnup and decay. Here I show  
3 a log, on the log scale, the decay years, and you can see  
4 from two years all the way out until you get very close to  
5 10,000 years, which is pointed out here, the inventory is  
6 roughly level. This is not a surprise, based on the half  
7 life of plutonium.

8           Furthermore, if you pick any single year and go  
9 across the burnup, you find that there is roughly a  
10 difference of a factor of three.

11           Well, the implication there is that if you randomly  
12 picked a time--as we do in our simulation--and then you look  
13 at the variation in burnup which you could get, there would  
14 only be roughly a factor of three for this component of the  
15 release occurring. Well, a factor of three is not very much  
16 in the scale and the precision to which the initial TSPA has  
17 been done, and so this is a contributor to the lack of  
18 difference in the overall.

19           Americium-241's kind of a pretty picture. It  
20 starts low, builds up, but its short half life means that by  
21 10,000 years, it dies off. However, you can see that there  
22 is a much greater variation in both time and burnup, and so  
23 you would expect to get greater variation from the releases  
24 of that, and Plutonium-240 is quite similar.

25           Well, I don't think that for the initial TSPA's

1 that we're doing it would be necessary to vary from the  
2 standard source term that we're using. It does not appear to  
3 contribute any more to the precision of the CCDF's than--  
4 there isn't any greater precision by using the detailed  
5 source term than the standard source term. However, it is  
6 clear that for individual radionuclides you can get a wide  
7 variation in the releases, and so if those radionuclides  
8 turned out to be the significant ones for releases such as  
9 due to aqueous transport or something, it might be necessary  
10 to be a little more specific about the nature of what the  
11 source term looks like.

12           For the TSPA-93, we may decide to include the  
13 inventories of individual radioisotopes for the aqueous  
14 releases from a detailed source term, and the last thing I  
15 want to point out is that what we used was the  
16 characteristics data base, based on the ORIGEN program from  
17 Oak Ridge, and this is what I'll call the old characteristics  
18 data base. It has a discontinuity in it based on the fact  
19 that this segment of the curve, the burnups calculated were  
20 done with a single enrichment for one of the points along  
21 here, and on this segment of the curve another enrichment was  
22 used. And as you can see, it produces a discontinuity in the  
23 inventory.

24           The new characteristics data base, which is  
25 literally being published as I talk, takes care of this and

1 uses the proper enrichment for each one of the burnup values,  
2 and so in the future, any detailed data base, and for that  
3 matter, the standard data inventory that we use, any detailed  
4 inventory or the standard one, we'll use the new quantities  
5 data base, which will eliminate this.

6 I should also point out that in your handout, the  
7 scale on that is correct, and on my beautiful color view  
8 graph, it's wrong. I picked up the wrong data.

9 Are there any questions that I can answer?

10 DR. DOMENICO: Well, thank you; thank you, Rallie.

11 Any questions from Board members? Any questions  
12 for any of the first three people? Yes, go ahead, Mike.

13 DR. APTED: Rallie, take this the right way, but it  
14 seems what you've--on the first day Dave Stahl defined source  
15 term as release from the EBS into the host rock. It seems to  
16 me what you've shown us, albeit important, has nothing to do  
17 with source term, and to keep calling it source term does a  
18 disservice, I think, both to the importance of your work and  
19 to the quite separate sort of work that other people are  
20 doing on the true source term. I mean, the definition Dave  
21 put up on the first day really is, I think, the one  
22 internationally people operate to. Human intrusion has  
23 nothing to do with source term, just as it has nothing to do  
24 with far-field modeling. It's something quite different.

25 DR. BARNARD: I agree completely, and in the paper that

1 I'm writing, I make a specific point in the second paragraph  
2 of saying: "Any further reference to source term which I use  
3 in this paper is my poetic license for talking about strictly  
4 the inventory," and I recognize that, and it's--maybe it's a  
5 shorthand that I shouldn't be using, but I do it anyway, so  
6 there.

7 DR. DOMENICO: Any other questions from Board members?

8 DR. APTED: I have one more for Mike.

9 On your slides where you were sort of normalizing  
10 to the NRC release rate for release from the near field, I  
11 didn't quite understand. The NRC release rate is on a  
12 nuclide-by-nuclide basis, so how can one--and normalized to  
13 the thousand-year inventory, so how can Carbon-14 have a  
14 normalized NRC release rate greater than one ever?

15 DR. WILSON: Mike Wilson.

16 I'm not sure I understand your question. Carbon-14  
17 has a limit which is something like  $10^{-5}$  per year, and if its  
18 release rate is higher than that, then it exceeds it. I  
19 calculated--for doing those, it was calculated for each--

20 DR. APTED: How can you reach more than 100 per cent?

21 DR. WILSON: It was calculated for each nuclide  
22 individually. Well, that just means that the release rate is  
23 great than  $10^{-5}$  per year. How--I don't see how that's  
24 difficult.

25 DR. APTED: Oh, okay. All right. I see, so a given

1 waste package--

2 DR. WILSON: Well, it's for all the waste packages  
3 together, not for a single waste package.

4 DR. APTED: Okay. We'll talk about it later, then.

5 DR. WILSON: Maybe the normalization is confusing you.  
6 I've divided by the  $10^{-5}$  in doing that.

7 DR. APTED: Okay.

8 DR. WILSON: When it said, "normalized release rate from  
9 EBS," I had divided by the  $10^{-5}$  per year to make a dimension-  
10 less quantity.

11 DR. APTED: All right.

12 DR. DOMENICO: Any questions from staff?

13 DR. REITER: Leon Reiter of the staff.

14 Mike, I wanted to ask a question about the EBS, the  
15 release rate, and I'm not sure if it's to you or to somebody  
16 in DOE. Is this the first quantitative calculation of a  
17 release rate? I think I've seen some qualitative estimates.  
18 Is this the first time it's been done quantitatively?

19 DR. WILSON: I'm not sure if I understand the question.  
20 There have been many quantitative calculations of source  
21 terms in the past.

22 DR. REITER: No, of the release rate.

23 DR. WILSON: Of release rates, certainly. I mean, for  
24 example, in the PACE-90, they had a whole report on  
25 calculations of release rates.

1 DR. REITER: And did they show, also, this exceedence  
2 (sic), as you indicate?

3 DR. WILSON: I can't remember if they did or not. One  
4 of the things that goes into that is differences in what you  
5 use for parameter values, and we used a much higher water  
6 flux than they used in PACE-90. I think Bill wanted to say  
7 something about that.

8 DR. O'CONNELL: Yeah. The PACE-90 calculations were  
9 published in a Lawrence-Berkeley lab report, as well as in a  
10 conference paper, and the release rates did appear to be  
11 higher than the NRC limits, and the report was qualified by  
12 the statement that these are hypothetical input values and  
13 bounding assumptions that were being used for the  
14 calculation, so the fact that the answer comes out higher  
15 does not indicate that the real case would be higher than the  
16 NRC's limit.

17 In other words, we started with a simplified model  
18 and bounding values for the input parameters, and the results  
19 appeared to be quite high. Now, that is just a starting  
20 point of an iterative number of calculations to refine the  
21 assumptions and data values.

22 DR. REITER: I understand. So you're saying the  
23 bounding case could be high. Is there any basis for DOE to  
24 assume that once they have a realistic estimate, it will be  
25 less than, and what's the basis for that?

1 DR. O'CONNELL: Yes. Now, taking this second generation  
2 simplified source term model as an example, we assumed that  
3 20 per cent of the fuel rods would be wet in a flow-through  
4 case, but yet with a influx of one liter per year, that's one  
5 drop of water every 30 minutes, and it most likely would just  
6 wet the pathway of one drop of water trickling down through a  
7 bundle of fuel rods. So perhaps one fuel rod or one-tenth of  
8 1 per cent, rather than 20 per cent. So there's a factor of  
9 a hundred or so that we were giving away by assumption  
10 because we did not have any real calculations of this  
11 internal hydrology yet.

12 And similarly, in the geochemistry, we were taking  
13 bounding values which may be a factor of ten or more too  
14 high, and in the diffusion release, we were just considering  
15 diffusion across a rock/rubble zone. We were not taking into  
16 account the resistance to diffusion of the materials inside  
17 the waste package.

18 So there are many areas where, with more data and  
19 more models, we could do much better, but we have just  
20 assumed that those good features are not present to make a  
21 simplified analysis as a first cut.

22 DR. DOMENICO: We're going to have to move along.  
23 Thanks, Bill, Mike, and Rollie.

24 We'll now hear from the PNL representatives. Dave  
25 Engel will give us some information on the source term views

1 in their performance assessment.

2       MR. ENGEL: Just to follow up a little on the question  
3 over here, the analysis that I will present is very similar  
4 to what we did in the PACE-90 work a year before, and so the  
5 results are very similar. And so, that'll be the same  
6 results pretty much that I show here, and so we can look at  
7 that, too.

8               Similar to what Sandia did, at PNL we did a  
9 parallel analysis on the total systems, and in particular, I  
10 did the source term analysis starting from the same, pretty  
11 much, scenarios and data base as what Sandia did, and so  
12 that's what I want to describe today.

13              What I want to talk about is briefly describe what  
14 we did in our total systems performance assessment, just  
15 briefly, also, describe the models, and look at some results  
16 of the analysis. And then we were asked, what happens to our  
17 release rates if we look at different thermal effects, and so  
18 we did a simple analysis to see what would happen if we  
19 changed the thermal loading on the analysis, and then just  
20 some little conclusions at the end.

21              For the TSPA, we looked at several different  
22 scenarios. In particular, we looked at the base case or the  
23 nominal cases of the repository. We looked at the effects of  
24 tectonics and the volcanic activity, and we also looked at  
25 human intrusion scenarios. Source terms were specifically

1 calculated for the base case and the human intrusion  
2 analysis, and that's what I'll describe.

3           At PNL, for doing this TSPA, the source term was  
4 calculated using the AREST code, which is a code that we  
5 developed at PNL. The transport was then calculated either  
6 using SUMO or using MSTS, and MSTS was used for the  
7 transported Carbon-14 in the gaseous phase, and then we  
8 calculated doses using either GENII or SUMO.

9           Specifically, again, the source terms were for the  
10 human intrusion scenario--and I'll briefly describe that in a  
11 few slides. The base case scenario or analysis was done on  
12 spent fuel and glass. We looked at different infiltration  
13 rates on the system; .01, .05, and .5 mm/yr, and then we also  
14 looked at diffusion-controlled releases. And again, we  
15 looked at gaseous releases where, one scenario, we looked at  
16 no infiltration and just the release of the gas. We looked  
17 at analysis where we had a low or .01 mm infiltration, and we  
18 also looked at the effects of container failures, where we  
19 looked at early failures whether we assumed that they failed  
20 as a uniform distribution between 300 and 2,000 years where  
21 the containment is all gone; and late failures, where we  
22 looked at 2,000 to 5,000 years.

23           For the human intrusion analysis, what we did was  
24 we assumed that someone drilled through the container and  
25 displaced a container down to a lower aquifer, either the

1 tuff aquifer or the carbonate, the Paleozoic aquifer, and  
2 then we used either an advective flow-through model, or we  
3 assumed a diffusive wet-continuous release model to transport  
4 to the host rock.

5           Uncertainties in this analysis were the different  
6 drilling times at which they would drill through the  
7 repository, and we also simulated the groundwater velocity in  
8 the aquifer.

9           And this is just a little picture to show the  
10 scenarios that we did look at and the source terms for the  
11 human intrusion scenarios where, again, we drilled through  
12 the repository and in one case, we would pull the entire  
13 container up to the surface and calculate exposure, looking  
14 at the entire contaminant. And in another analysis, we would  
15 drill through the repository, miss a container, and exhume  
16 the rock and the soil which is contaminated by the release;  
17 or we would drill through the container and displace a waste  
18 package down to the lower aquifers, and then transport it  
19 away.

20           I apologize for my cold, so--good timing. The base  
21 case analysis, again we used gaseous release of Carbon-14,  
22 where we looked at as soon as a container has failed, we  
23 would have an instant release of the gaseous parts of Carbon-  
24 14 where we'd assume it's all gone in a single year out of  
25 the EBS, and we coupled that with a slower release when

1 there's a water environment, and we coupled those together  
2 and in MSTS we calculated the gaseous release.

3           And then we looked at the waterborne releases, when  
4 there's water after container failure, looking at our flow-  
5 through release models and what continuous release models,  
6 and in this analysis, since it was for this total systems  
7 analysis, we kept it quite simple, and we assumed that the  
8 cladding was no barrier to the transport. We simulated  
9 containment failure and we assumed once the container was  
10 failed, that we lost the entire containment, and release for  
11 the waterborne release then would start releasing as soon as  
12 there's water in the environment, as soon as the temperatures  
13 dropped below some re-saturation level or re-wetting level.

14           And in this analysis we looked at the uncertainties  
15 included; the simulation of a containment failure as a  
16 uniform between 2,000 and 5,000 years for the waste packages.  
17 We simulate temperature for each single waste package, and  
18 then we looked at temperature-dependent boundary conditions  
19 at the waste form surface, where we did calculations using EQ  
20 3/6, which was described in its entirety yesterday--well, not  
21 entirety--but we calculated solubilities as a function of  
22 temperature and used those values in our analysis, or when we  
23 used glass, we developed a glass-reactive controlled model,  
24 which calculates a concentration of the glass at the waste-  
25 borne surface as a function of temperature and such, and I'll

1 describe the briefly.

2           This picture shows basically the design that we  
3 used, and the same design that was used earlier in the Sandia  
4 analysis, where again, we place a container in this borehole  
5 where there's a 3 cm air gap to the host rock, and in this  
6 analysis, we're looking at a wet drip water environment,  
7 where we assumed that there's water going to be dripping onto  
8 the container at some infiltration, and we assume that the  
9 water can drip onto the container, flow through the  
10 container, and drip out the bottom after it has dissolved the  
11 fuel.

12           In our wet-continuous or moist-continuous  
13 environment, we assume that there's a rubble-filled zone  
14 surrounding the waste container, allowing a diffusive pathway  
15 of water to flow into the waste container, and then also flow  
16 out of the waste container, and use diffusive release models  
17 in this analysis.

18           In the AREST code, we've developed--or Pete McGrail  
19 at PNL has developed a glass dissolution model, similar to  
20 what Bill Bourcier talked about yesterday. We used EQ 3/6 to  
21 estimate concentrations of different elements as a function  
22 of reaction progress. From that analysis, using EQ 3/6 as a  
23 function of temperature, in the AREST code we use a math  
24 balance analysis to estimate or calculate reaction progress  
25 as a function of the glass dissolving, and also transport

1 away of the waste as it dissolves. And so we calculate a  
2 reaction progress and we go to the analysis using EQ 3/6, and  
3 at a given reaction progress, we can estimate a concentration  
4 at the waste form surface for each element, and use that--or  
5 each nuclide, and use that concentration to transport to the  
6 host rock and out of the EBS.

7           Next I'd like to show some specific cases, just  
8 some examples of typical analysis or results that we got for  
9 this TSPA. Here's a human intrusion analysis where we  
10 displaced a container down to the tuff aquifer, and then used  
11 our release models for transport into a host rock, which was  
12 one meter away from the waste container. And in this  
13 analysis, we see that the nuclides that are controlled again  
14 by the alteration rate of the waste form, the fission  
15 products, are the higher released nuclides, where again, we  
16 have the--as shown earlier--the slower releases of the  
17 solubility-limited models that dissolve--or are limited by  
18 the solubility. So that's just a typical result from the  
19 human intrusion, and that's about all I want to say about the  
20 human intrusion, just to show a little results, and so I'll  
21 skip the next slide.

22           The base case analysis, where we look at--in this  
23 case, we're looking at an infiltration rate of .5 mm/yr.  
24 These results are very similar to what we would get with the  
25 different infiltration rates. Again, we used .01 mm/yr and

1 .1 mm/yr, and in our models, in our analytical models, the  
2 flow rate is a scaler on the equation. That's if we have  
3 lower infiltration rates, the release rates will be lower,  
4 and such if it's higher. And so again, we see that our  
5 alteration, dissolution-controlled nuclides are the release  
6 rates that are much higher.

7           And we see the effect here of the simulation of the  
8 different waste containers, where we assumed that they failed  
9 between 2,000 and 5,000 years. But again, we don't get any  
10 releases until we have water actually in the system, and in  
11 our analysis, it was somewhere around 1500 years or so in  
12 most waste packages until the temperatures actually dropped  
13 below some saturation value. And these results are similar  
14 to what we got in the PACE-90 work earlier analysis.

15           And here I'm just showing the fractional release  
16 rates, where we just normalize the release rates by the  
17 thousand-year inventories of each of the nuclides, and we see  
18 that the highly-soluble nuclides are up above  $10^{-4}$  parts per  
19 year in this analysis, where here we see the solubility-  
20 limited models are much lower in release rates.

21           Then we looked at glass as a waste form, and used  
22 our glass dissolution or our coupled reactive model for  
23 calculating the concentrations at the waste-borne surface and  
24 the transport, and in this analysis, the alteration-limited  
25 nuclides have a much lower release rate due to the

1 dissolution of the glass and such. And so we see that the  
2 alteration-limited nuclides are not mainly the dominant ones  
3 in all cases. Here we see that uranium is much higher in  
4 this analysis with the glass. That's due to a couple things,  
5 the dissolution and the kinetics of the waste of the glass,  
6 and also due to shared solubilities with Uranium-235 and 238,  
7 and there's more 234 in the glass analysis in the waste form  
8 than for the spent fuel. Thus, the shared solubility is  
9 going to be higher for the 234.

10           Just looking at the same analysis, normalized by  
11 the thousand-year inventory, the fraction of release rates in  
12 this analysis, we see that the release rates are much lower  
13 than earlier. In fact, none of them exceed  $10^{-5}$  parts per  
14 year.

15           Looking at an analysis on Carbon-14, where we're  
16 looking at .05 mm/yr and the release of Carbon-14, where this  
17 early release of Carbon-14 is entirely due to the gaseous  
18 release. We assumed here that the containers failed between  
19 300 and 2,000 years, and there's no water in the environment  
20 at that time due to the higher temperatures, and we assumed a  
21 uniform failure of the containers and the instant release of  
22 the Carbon-14, so we have a uniform release of the Carbon-14  
23 in gaseous phase. And then the later release is when the  
24 water reenters the system and transports the Carbon-14 away.

25           And then just the same analysis again, normalized

1 by the thousand-year inventory, and just looking at the  
2 magnitude of around  $10^{-4}$ , due, again, to some assumptions  
3 about how we failed the container, how fast the release rate,  
4 and also, the alteration of the waste form producing--in this  
5 analysis, we used for the waterborne releases, we used an  
6 alteration rate of  $10^{-3}$  parts per year, so then we assumed  
7 that the waste is going to be all dissolved after a thousand  
8 years, and this gives us high release rates. So that was  
9 basically the analysis that we did a year ago for the TSPA,  
10 the parallel analysis to Sandia's results and such.

11           And then we were asked to look, you know, at the  
12 new thermal scenarios and the new waste package and such, so  
13 what we did was a simple analysis here and to see what higher  
14 thermal loadings. I didn't do a--we didn't do a full thermal  
15 analysis on this. What we simply did, we'd just see what  
16 higher temperatures and see how they're going to affect  
17 release rates.

18           We know looking at our release models, that the  
19 release is going to affect the re-saturation times, time at  
20 which releases are going to be able to start due to the later  
21 times at which it's going to drop below the re-saturation  
22 time. In our analysis, we used temperature-dependent  
23 solubility, so that will affect our release rates, and we  
24 also have our glass dissolution model, which is temperature-  
25 dependent.

1           So what we did, we just simply increased the  
2 temperature profiles in our analysis. We looked at spent  
3 fuel, the same nuclides that we're looking at, the  
4 solubility-limited and the alteration rate-limited models,  
5 and then we also looked at the effect on glass with a  
6 groundwater-coupled reactive model to see how it would affect  
7 the release rates.

8           And this just simply shows a very simple analysis  
9 that I did. We just increased the thermal temperatures, and  
10 just to get a brief idea of how it's going to affect the  
11 release rates, instead of doing a full, detailed analysis.

12           Looking at some of our solubility-limited nuclides,  
13 we see here that our delay due to the re-saturation because  
14 of higher temperatures, we see this in all of our release  
15 profiles here, that it's going to be released at a later  
16 time. And we also see here, due to the effect of the  
17 solubility in our calculated--or temperature-dependent  
18 solubilities as we calculated with EQ 3/6, that the  
19 solubility is lower in the higher temperatures, because we  
20 estimated the solubilities, using EQ 3/6, and we got lower  
21 solubilities with the higher temperatures and thus, in this  
22 model, the release rates are lower.

23           With our alteration rate-limited nuclides, which  
24 are entirely limited by the dissolution of the waste form,  
25 temperature does not affect that analysis since we assume

1 that it's a constant release into the water, and so it has no  
2 effect on the magnitudes. It does delay it, but no affect on  
3 the magnitudes.

4           Then with our glass dissolution or coupled reactive  
5 model, we see that there are different effects. For uranium,  
6 the concentrations at the waste form surface are the same  
7 with higher temperatures and lower temperatures. It didn't  
8 change it at all. For neptunium, it actually increased at  
9 higher temperatures the concentrations, and then for  
10 plutonium, it lowered the concentrations at the waste form  
11 surface for higher temperatures.

12           And for a couple other nuclides, we see that it  
13 actually increased the concentrations at the waste form  
14 surface, using our glass model. So that just briefly  
15 describes just a simple analysis that--just a look at how it  
16 would affect our release calculations.

17           The last slide is just some conclusions from the  
18 analysis that I just presented. In the TSPA source term  
19 analysis, we had some of the nuclides that did exceed the NRC  
20 regulatory criteria, same as what Sandia had. Several  
21 different assumptions could explain this; the dissolution  
22 rate of the waste form, because we saw that the alteration  
23 rate limited nuclides were the ones that exceeded the  
24 regulatory criteria, and we used a constant dissolution rate  
25 for all of the simulated waste packages and such.

1           What this does mean to our modeling is that we do  
2 need some more detailed modeling; in particular, the more  
3 coupled reactive transport models, similar to our glass  
4 dissolution model that we have in the AREST code. We want to  
5 develop a spent fuel dissolution model using the analysis by  
6 Walt Gray and Bob Einziger. We need to develop a model that  
7 will incorporate their work, similar to our glass modeling.

8           And then, just briefly, we looked at the effects of  
9 higher thermal loading, and we saw that in all of our  
10 analyses, it delayed the transport due to the re-saturation  
11 in the higher temperatures, but we also saw that in some  
12 cases it lowered release rates, some cases it had no effect,  
13 and in some cases it actually increased the release rates.  
14 And so this points to--there needs to be more modeling in  
15 this looking at the thermal effects and the new designs,  
16 which we haven't looked at, and a lot more analysis.

17         DR. DOMENICO: Thank you, Dave.

18           Are there any questions from the Board?

19         DR. GARISTO: Dave, how did you calculate the re-  
20 saturation time as a function of temperature?

21         MR. ENGEL: The saturation as a--

22         DR. GARISTO: Re-saturation time as a function of  
23 temperature.

24         MR. ENGEL: All we did was we simulate temperature  
25 profiles, and we just pick a temperature at which we assume

1 that it's going to be below that temperature, it's going to  
2 start re-wetting. And then looking at our temperature  
3 profiles, we just pick that value off. I mean, we simulate  
4 temperature distribution for each waste package, and we just  
5 have a constant value for at this re-saturation temperature,  
6 and at that rate--at that temperature and below, there's  
7 going to be re-saturation.

8 DR. DOMENICO: I have a few questions, Dave. When you  
9 say coupled, do you mean that the advection may impede the  
10 kinetics like might be expressed by a DOM (phonetic) colon  
11 number? What do you mean by your coupled reactive model?  
12 What is coupled there?

13 MR. ENGEL: Well, okay, I just want to paraphrase. This  
14 isn't my expertise, but I can talk a little about it.

15 It was developed by Pete McGrail. He's a  
16 geochemist at PNL, and I know Bill Bourcier talked about it  
17 yesterday, but what we do is we couple the dissolution of the  
18 waste form with the groundwater, and in our model, we also  
19 look at the effects of a backfill region. We can couple in  
20 the backfill region, and also, iron content, if the iron  
21 corrosion of, say, the waste container is corroding away. In  
22 EQ 3/6 they have the capability of modeling at the waste form  
23 or the concentration.

24 DR. DOMENICO: Also, have you modified the AREST code to  
25 take into account temperature dependence? Is that what we

1 were seeing here?

2 MR. ENGEL: Right.

3 DR. DOMENICO: What--just basically, quickly--what are  
4 the physics imbedded in that AREST code? I mean, it sounds  
5 like you have a robust source term model. It appears that  
6 way anyway. What's involved in there?

7 MR. ENGEL: Well, our models, our analytical models in  
8 the AREST code were developed mainly by Tom Pigford's group  
9 at University of California-Berkeley.

10 DR. DOMENICO: Okay.

11 MR. ENGEL: And for instance, most of the models that  
12 they developed were a constant concentration at the waste  
13 form surface.

14 DR. DOMENICO: Yeah. They're pretty heavy into  
15 diffusion control, also.

16 MR. ENGEL: Correct, but they do have models, later  
17 models for advection for the Yucca Mountain site, and we've  
18 discussed with them, and such that varying, say,  
19 concentrations at the waste form surface, and if that would  
20 affect the models and such, and it possibly could. And  
21 that's why we feel that maybe the analytical solutions that  
22 we have in the AREST code currently are limiting in that  
23 sense, because the models were developed for constant  
24 boundary conditions, and we've basically stretched that a  
25 little.

1 DR. DOMENICO: Any further questions? Don?

2 DR. LANGMUIR: Langmuir; Board.

3 I've got a more general question, Dave, which maybe  
4 someone else needs to answer, but I guess since you happen to  
5 be here, I'll start with you.

6 On your plots, you showed obviously different  
7 radionuclides coming off, depending on the scenarios you  
8 chose, and that piqued my question, my general question,  
9 which has to do with the relative release rates from glass,  
10 defense waste glass versus spent fuel.

11 Presumably, the glass will comprise 10 per cent or  
12 so of the total inventory in the repository, but something we  
13 haven't--I haven't learned about or haven't assimilated here  
14 is the relative rates of release of radionuclides from glass  
15 or fuel, and if the rates are much higher from fuel, its  
16 impact, if there's a breach, could be much greater than the  
17 10 per cent.

18 So I guess if someone could address for me the  
19 relative rates of release--and that's going to affect the  
20 individual radionuclides that get out there as well, since  
21 they differ in the fuel from the glass. I guess that's my  
22 question for anybody who feels they could comment on that,  
23 I'd be interested; relative release rates and that impact on  
24 which radionuclides are the issue.

25 DR. BATES: John Bates. I made a presentation on glass

1 yesterday.

2           In my presentation, I described that, you tell me  
3 the conditions, and I can tell you the release. Some of the  
4 release rates for glass are, as I showed in the final  
5 release, quite rapid. In addition, if the glass is aged and  
6 it contacts water, then that would also be quite a rapid--  
7 it'll be a pulse and it'll affect the radionuclide  
8 distribution and release, and it'll affect the subsequent  
9 reaction of the glass.

10           So depending upon what the scenario is, you have  
11 wide range of release for glass, and I suspect that in some  
12 of those cases it could be greater than it would be for spent  
13 fuel.

14       DR. LANGMUIR: Sounds like something someone ought to  
15 worry about.

16       DR. DOMENICO: Any further questions from Board members?

17           (No audible response.)

18       DR. DOMENICO: Staff questions? We have a few minutes.  
19 We can entertain a few questions.

20       MR. CURTIS: I have a question about--oh, Dave Curtis  
21 from Los Alamos.

22           I have a question about your slides, I guess, 22  
23 when you show the relative release rates of cesium and  
24 technetium. I wondered why those are different. Is the  
25 assumption that those are both infinitely soluble? Shouldn't

1 they have the same form?

2 MR. ENGEL: Which?

3 MR. CURTIS: Well, 22 is--there's a couple of them,  
4 but--

5 MR. ENGEL: These ones?

6 MR. CURTIS: Yeah.

7 MR. ENGEL: That's due to the retardation in the  
8 transport.

9 MR. CURTIS: Oh, so this has transport built into it?

10 MR. ENGEL: Right. And the cesium has a much higher  
11 retardation.

12 DR. DOMENICO: Transport where; within the barrier?

13 MR. ENGEL: Just the transport to the host rock, across  
14 either the rubble that--

15 DR. DOMENICO: Okay. Anything further from the  
16 audience?

17 (No audible response.)

18 DR. DOMENICO: Well, we're right on--

19 DR. REITER: I have a question. You indicated early on,  
20 and we know that PNL did individual dose estimates along with  
21 cumulative release. If the regulations are, indeed, changed  
22 from cumulative release to individual dose, can you give us  
23 any insight as to how one might look at the source term  
24 differently and how this might affect investigations?

25 MR. ENGEL: That's a good question, and I'm not an

1 expert to answer it, but obviously, if we're just looking at  
2 mainly doses and we don't need to look at the NRC criteria as  
3 such, as long as we can meet the dose criteria with a source  
4 term, then maybe we don't need as detailed an analysis. But  
5 we need to look and make sure that the repository--there are  
6 releases from the source term, and we need to know what they  
7 are.

8           Anyone can jump in and help on that one.

9           (Laughter.)

10          DR. O'CONNELL: Bill O'Connell from Livermore.

11           When you take transport and host into account, then  
12 different radionuclides would have a different weighting  
13 factor than they have in either the NRC's release rate limit  
14 now, or in the EPA's cumulative release rate, where there are  
15 weighting factors. So perhaps some other radionuclides would  
16 rise to larger relative importance because of their  
17 environmental transport and uptake, but that would just  
18 change the mix of radionuclides which are at the top of the  
19 list. It wouldn't be a major change as far as the source  
20 term goes.

21          DR. DOMENICO: Well, we're right on schedule. Why don't  
22 we take that fifteen-minute break that we moved up, and then  
23 we'll hear from EPRI.

24           (Whereupon, a brief recess was taken.)

25          DR. DOMENICO: Our next presenter, Bob Shaw from EPRI,

1 will give us some information on the source term used in  
2 their performance assessment.

3           Bob?

4           MR. SHAW: Thank you, Pat; appreciate the opportunity  
5 and the invitation from TRB to come and talk a bit about the  
6 work that we've done in performance assessment, focusing on  
7 the source term.

8           Our performance assessment model does calculate  
9 radionuclide releases to the accessible environment. It uses  
10 a probabilistic-based approach, using logic diagrams to  
11 calculate CCDF's, even though CCDF's may soon be outmoded if  
12 the President does, in fact, sign the National Energy  
13 Strategy Bill and we change to a dose-based environment. It  
14 uses individual experts to develop the nodes on the logic  
15 tree, and that's a very important and vital part of the  
16 analysis that we do, so we have individual experts, not group  
17 expert judgment at this stage, but each one going out and  
18 looking and assessing the current state of the technology  
19 and, through that, developing the logic tree node that's the  
20 responsibility of that particular individual.

21           Let me also state that the approach is meant to be  
22 a realistic, not a conservative kind of a calculation, but a  
23 realistic calculation of what we expect the release to the  
24 accessible environment would be under what we presently  
25 understand to be the best possible estimate of what will

1 actually occur at Yucca Mountain.

2           It relies very heavily on more detailed models and  
3 analysis. It is meant to be a top overview kind of analysis,  
4 so we look at that for the controlling mechanisms and the  
5 parametric values. We do not attempt to include each and  
6 every aspect of what might happen under every possible  
7 scenario, but rather, to filter through and get the most  
8 important aspects to include in our model and, as such, we  
9 rely very heavily on the work of others that you've heard  
10 here today.

11           The overview of my presentation is it will be in  
12 two portions. The first portion will be to review with you  
13 the source term results from our previously published work.  
14 This is our most recent report issued in May of 1992, which  
15 was the Phase 2 demonstration of risk-based approach. Those  
16 of you who remember Phase 1, it was meant to be illustrative,  
17 show how the method would work. Phase 2 is, as I mentioned  
18 before, meant to present a realistic estimate of what is  
19 actually the release of these radioisotopes to the  
20 environment.

21           Subsequent, and actually, somewhat previous to  
22 this, we began some initiative that says how can we refine  
23 the results that we have, and a lot of the refinement that we  
24 have been doing over the last six months or so has focused on  
25 the source term, so I will review in the second portion of

1 the presentation some recent refinement that we have in the  
2 source term analysis. The refinement will describe,  
3 actually, input because we do not have results yet from that  
4 refinement as it's taking place.

5           To take you from the end results of the first phase  
6 of this, the Phase 2 reports, the results are displayed in  
7 the following form. This is a CCDF, with the EPA's current  
8 limits expressed as the staircase on the upper right. You  
9 can see the various radioisotopes and the relative  
10 contributions that they make to the total CCDF. If you were  
11 actually to sum these together--I don't have a summed curve  
12 on here because it further complicates things, but because  
13 it's a long scale, the sum scale is not much different than  
14 the outside envelope that you would construct by going  
15 through the outside here. There are some additions, some  
16 places where they are fairly close, and there are some  
17 additions. Because it's a log scale, though, you don't see  
18 too much of that.

19           An important feature of this is that you do see an  
20 order of magnitude difference between the limits and the  
21 calculations that we come up with.

22           Considering the source term itself, and adhering as  
23 best I can to Mick Apted's rules about what the source terms  
24 are, this is meant to be the release of radionuclides from  
25 the near field, and as such, we have seen this has three

1 aspects. The first is the waste package degradation; the  
2 second is the dissolution of the waste once that degradation  
3 has taken place; and the third is the transport of the  
4 released radionuclides. That transport, in this case, is  
5 meant to be over a very limited basis, but it's the transport  
6 that takes the radioisotopes from the spent fuel to the point  
7 where the hydrology is considered far field, so that's what  
8 we consider the transport processes to be taking place here.

9           Reviewing the logic tree that we have that makes up  
10 the core of our calculational procedure, it is one which is  
11 an ordered calculation, starting with infiltration, a change  
12 in water table from that infiltration, earthquake occurrence,  
13 the change in water table from earthquakes, volcanic dikes,  
14 the repository temperature, borehole fractures, the  
15 engineered barrier system, solubility and dissolution,  
16 diversion of infiltration, fracture and matrix coupling,  
17 matrix sorption, saturated flow velocities, and finally,  
18 human intrusion.

19           The ones that I've circled in blue is the  
20 particular area that I consider source term. It is somewhat,  
21 but rather mildly affected by the ones that are in front of  
22 it, and I'm not going to consider the influence that they  
23 have on it. In addition, the borehole fractures, although an  
24 important part of this, will not be a prime consideration.  
25 So I'll be talking about repository temperature, EBS, and

1 solubility and dissolution as the primary ingredients of the  
2 source term here.

3           So starting off with waste package degradation, as  
4 many of you are aware, we use Weibull statistical  
5 distributions to describe the degradation and the loss of  
6 integrity of the various features. We do include both  
7 container and cladding failures. Our experience in the  
8 utility industry these days is that zircaloy, after it comes  
9 out of the rather aggressive environment within the reactor,  
10 is found to be on the order of one/hundredth of one per cent  
11 of the fuel rods that actually failed. That's a remarkable  
12 figure, I think, under those particular considerations, and  
13 it's quite a statement to the fact that fuel vendors have  
14 done a lot to understand what causes those kinds of failures.

15           So we do include the zircaloy in addition to the  
16 outer container, two different Weibull distributions, and in  
17 each case we will define--we do define threshold failure  
18 times, mean lifetimes, and failure rate at mean lifetimes.  
19 In other words, we use the three-parameter, Weibull-type  
20 distribution.

21           Some have asked why we use Weibull; because it  
22 seems to express in the best fashion that we can see the  
23 statistical distribution of failures that come from  
24 manufacturing-type of processes.

25           In order to determine in some reasonable fashion

1 the values for these three lifetimes, we use the degradation  
2 modes and failure mechanisms. Now, that means the  
3 environment, the materials, the closure, and the thermo-  
4 mechanical history. Here, in particular, this makes  
5 reference to the container. The environment, of course, is  
6 the chemical environment that one will experience at the  
7 outer surface of these containers, the particular material  
8 that has been chosen for that closure because, in many cases,  
9 we expected that this will be a welded system and, as a  
10 result of that, heat-affected zones may be the primary area  
11 in which you do eventually get failure; and then the thermo-  
12 mechanical history, meaning the manufacturing history of the  
13 particular system.

14           We use these, then, to deterministically come to  
15 the Weibull parameters that are used in our particular  
16 distributions. In a similar fashion for the cladding, as you  
17 heard yesterday, the primary sources of loss of integrity  
18 will undoubtedly be creep rupture and hydride reorientation,  
19 so we use those again to estimate what we think are  
20 reasonable failure times, mean lifetimes, and failure rate at  
21 the mean lifetime.

22           Considering the temperature profiles that one might  
23 anticipate within the system, we have selected three. The  
24 particular order may be awkward, not going alpha, beta,  
25 gamma, but three temperature profiles have been considered.

1 One, of course, is the hot profile that says we get  
2 significant temperatures increase and, in this case, over a  
3 period of about a thousand years, in which the temperature of  
4 the system is above 100° C; a second profile, gamma, in  
5 which we consider that heat pipes and other effects take  
6 place that allow the system to go to 100, but not above  
7 100°, so that the boiling point is retained; and thirdly, a  
8 cold system, where decay has taken place because we've stored  
9 the fuel for a longer time or spread it out within our  
10 repository, meaning that we have a temperature pattern that  
11 is always below 100° C.

12           When we look at the entire repository, however, we  
13 come to the conclusion that there will be a fraction of the  
14 fuel that will have different curves representing that. For  
15 example, if we start out with what we term the hot  
16 repository, and we consider there's a 60 per cent probability  
17 at this stage that we will end up with a hot repository.  
18 That, in our estimation, would have 90 per cent of the  
19 containers represented by Curve A, and 10 per cent  
20 represented by the curve gamma. So we will have 90 per cent  
21 of those being hot, above 100° C, and 10 per cent being  
22 represented as going to the boiling point, but not above.

23           And then, similarly, you can see the 30 per cent  
24 for the warm, and 10 per cent for the cold. In the cold

1 system, we consider that everything, all the containers would  
2 be following a pattern described by beta. That's the curve  
3 that's always below 100° C.

4           In addition, when we look at the engineered barrier  
5 system and decide what it's going to look like, we first of  
6 all decided there could be three different types of  
7 containers. Type 1 we determined would be 304L stainless  
8 steel; secondly is an alloy 825; and the third is a multi-  
9 barrier, and you can see that what we've decided is that  
10 depending on whether you have a hot, warm, or cold  
11 repository, the design decisions would be altered, depending  
12 on which of these you were going to have.

13           So that we expect that if you have a hot  
14 repository, there's a 70 per cent chance that Alloy 825 will  
15 be chosen, 10 per cent it would be multi-barrier, and so on  
16 and so forth. So this means that when you begin to talk  
17 about thermal effects, it's wrapped up, in our model at  
18 least, with a design decision as well. So it's not  
19 completely independent in that sense, but we think that does  
20 represent the process that would take place in the design  
21 decisions.

22           When we look at the sensitivity of our results to  
23 the selection of the engineered barrier system, it looks  
24 somewhat like this. Let me go back just a second here and  
25 describe to you what I mean by what we do here for

1 sensitivities.

2           When we make our calculation here, every one of  
3 these scenarios is included in our calculation, and they're  
4 weighted according to the probability, and of course,  
5 there're probabilities associated with each of these as well,  
6 as I showed you in the previous diagram. So when you make a  
7 calculation, you include all of these.

8           When we want to look at the sensitivity to a  
9 particular parameter, we then choose that parameter and  
10 change the probabilities; for example, looking at an  
11 engineered barrier system, and we want to know, what is the  
12 sensitivity to this selection process. We will, in turn, say  
13 100 per cent, or 1.0 is stainless steel in all these cases.  
14 So we put zero to the others, et cetera, and we go through  
15 that process for each of the three, and that's the way that  
16 we investigate the sensitivity of the selection of the  
17 engineered barrier system to our particular calculation of  
18 the CCDF.

19           And you can see the results here, which show that  
20 the integrated case, which appropriately weights all of  
21 these, is very similar to the Alloy 825. Stainless steel is  
22 slightly less effective, giving a slightly higher  
23 concentration of radioisotopes, and the multi-barrier system  
24 gives you a significant additional protection, on the order  
25 of one and a half orders of magnitude better as you go

1 through the multi-barrier system.

2           When we look at the influence or sensitivity  
3 regarding the choice of whether it is a hot, a cool, or a  
4 warm repository, we see less sensitivity. We do see some  
5 benefits to going to cool, but you must again remember that  
6 wrapped up in this choice is the decision that's made, the  
7 design decision with regard to the material.

8           Considering, then, the next step, which says once  
9 you've lost the integrity of the container and the zircaloy,  
10 what happens, then, to the radioisotopes? So the dissolution  
11 and the transport, then, first of all encompasses the release  
12 modes, and the first is, of course, dry, in which case we  
13 have no release pathway other than the gaseous transport.  
14 Second is the wet drip. The container fills to the  
15 penetration. We do not consider that there is a hole in the  
16 top and also a hole in the bottom. We consider that  
17 somewhere on the system there's a hole, and the water goes in  
18 and it fills until it gets that hole, and then release takes  
19 place of those radioisotopes that are contained within that  
20 water. And then, third, is the moist, where you have a  
21 diffusive and advective pathways as a result of moisture  
22 carrying over the surface and holes being through the  
23 container.

24           We have also have chemical constraints on release  
25 that are similar to those that have already been discussed

1 here. First is dissolution, which, of course, will be  
2 affected by the alteration rate for certain isotopes, or the  
3 reaction rates for certain other isotopes, or it may be the  
4 solubility limit that limits the transport of the  
5 radioisotopes themselves. So we do that isotope-by-isotope  
6 to determine which is the appropriate constraining factor  
7 there.

8           The picture that we use does take into account that  
9 the various radioisotopes are contained in different  
10 locations, and starting at the outside with the cladding, you  
11 do have Carbon-14 on the cladding. Actually, further outside  
12 than that you have a crud layer which has Carbon-14 within  
13 it. Then there is a gap that contains this inventory of  
14 radioisotopes, the grain boundaries which we consider to have  
15 this inventory of isotopes, and then the UO<sub>2</sub> matrix itself,  
16 with the actinides and about 98 per cent of the fission  
17 products. And so we do relegate the inventory of  
18 radioisotopes into these various categories, and on the next  
19 table it gives you in a little more detail, in numerical  
20 detail, just where we consider these various radioisotopes to  
21 be.

22           And you can see that you have the outer surface  
23 layer and the gap that has about 2 per cent of the Carbon-14,  
24 and the other 98 is contained within materials which is much  
25 more slow to release. Most of the other radioisotopes are

1 contained within the  $\text{UO}_2$  matrix, with some small amount or  
2 small fraction being contained in the gap and the grain  
3 boundary. So this is our current model for, numerically, the  
4 distribution of those radioisotopes.

5           The other feature that's important here is the one  
6 of solubility, and one of the questions we looked as we went  
7 to a temperature-dependent system was, what is the effect of  
8 temperature on solubility? But to start off there, we looked  
9 at what's the range of solubilities for these various  
10 radioisotopes, and if you look a little closely at these,  
11 these ranges are atrocious.

12           To take an example, neptunium goes from  $10^{-4}$  to  
13  $10^{+2}$ , Americium,  $10^{-7}$  to  $10^{-1}$ , and you wonder how anyone can  
14 possibly come up with a range that's quite so widespread.  
15 The manner in which we did this was to go back and look at  
16 the data that's available on these various radioisotopes.

17           The first crucial question, of course, is, what is  
18 the chemistry that they are experiencing? What is the pH, et  
19 cetera? The other, what is the temperature, pH, and oxygen  
20 concentrations? Well, those are very big unknowns, and as we  
21 look at the range of chemistries than can be present in the  
22 aqueous conditions and we look at the solubilities, that  
23 leads us to these kinds of ranges. So this is a result of  
24 the uncertainty of the chemistry that leads us to such a wide  
25 range in the solubility estimates that we have for some of

1 these radioisotopes.

2           As a result of that, we say, putting temperature  
3 effects in here is nonsense. The temperature effects are  
4 significantly less than the ranges that you see here, so we  
5 don't bother with them at this stage. We feel that's not a  
6 sensitive factor, considering the unknown of the chemical  
7 condition itself that would exist at the point of  
8 dissolution.

9           I should make one other point here. What we've  
10 called the moderate is meant to be our best estimate of what  
11 we think would be in there. It's in no way some statistical  
12 difference between these two. It's meant to be our expert's  
13 best judgment of what we think the chemistry and the  
14 resulting solubility most likely will be in that particular  
15 environment, and then we use each of these three cases in our  
16 logic diagram when we consider solubility, and we do consider  
17 that there's a 90 per cent chance that the moderate  
18 solubilities on that table will be appropriate, and 5 per  
19 cent chance that the high and the low will be the actual  
20 solubilities that will exist at the time that the dissolution  
21 takes place.

22           When you look at the sensitivity of the results to  
23 the solubility, you find that it's a bit more dramatic than  
24 the other sensitivities, and as a matter of fact, I believe  
25 this is the largest sensitivity we have of all of those that

1 we investigated as we went through our nodal analysis. So  
2 you can see that in going from the integrated--of course, the  
3 moderate and the integrated are about the same since this is  
4 90 per cent of the integrated case, but you can if you go to  
5 very low, it's a very significant decline, and if you go to  
6 high, you get to some points where it's pretty close to the  
7 limit that the EPA has established.

8           Now I want to go into the second portion of this  
9 presentation, which talks a little bit about the refinements  
10 that we have been undergoing recently. We had some meetings  
11 with Lawrence-Berkeley Lab, U.C.-Berkeley, Lawrence Livermore  
12 Nuclear Lab, and Sandia National Lab in the early parts of  
13 last summer to discuss with them what are the particular  
14 items in our performance assessment that would benefit from  
15 some upgrading, and four items are listed here that were the  
16 prominent outputs of that.

17           Thermal loadings and the waste containers. There  
18 are some changes. We had these in there before, but there  
19 are some changes that I'll show you in just a moment. These,  
20 of course, are design parameters, and it's important that as  
21 we think through some of these models, we recognize that  
22 things like solubility are uncertainties in the physics, but  
23 designs are just as much uncertainties, but they're, of  
24 course, of a very different nature. Three heat-transfer  
25 mechanisms: conduction, convection, and heat pipe, and four

1 time-temperature curves.

2           And just to further confuse those of you who know  
3 Greek, we have placed now another curve out of order with  
4 regard to the Greek alphabet, but what you see is the alpha,  
5 gamma, and the beta are the same curves as I've put up  
6 before, but we now have a delta, which says we have high  
7 temperature for a very much longer period of time; that over  
8 a period of 10,000 years, we are keeping the waste canisters  
9 above the boiling point. So that's the addition to our time-  
10 temperature curves, which gives us the refinement.

11           Now, the manner in which we have handled the  
12 variety of aspects we were considering here is illustrated in  
13 this particular chart. To start off with, this is the  
14 fractions of the repository in different environments for the  
15 average power distribution of 57 kW/acre. This is  
16 illustrative in the sense that there are others which have  
17 different heat loadings, so this is for the intermediate heat  
18 loading.

19           Taking that, then we can say, well, we think  
20 there's a 50 per cent chance in this case that we'll have  
21 conduction-dominated heat transfer; 20 per cent that we'd  
22 have high permeability; and 30 per cent that water would be  
23 mobile in the fractures. And then you can see that for each  
24 of these cases, we have said, "what's the probability that  
25 you would have dry?" and "if you have dry, what are the

1 temperature curves that would represent what fraction of the  
2 packages, of the waste containers that are there?"

3           So this is the whole matrix, then, adding up to  
4 one, that says what fraction of the waste packages are likely  
5 to be at that particular, either temperature or water,  
6 condition for each of these cases. And so this is the manner  
7 in which we have developed the probability matrix that's  
8 associated with each of these conditions as you pass on  
9 through that.

10           Now, we're at the stage now of having completed the  
11 collection of relevant data from the experts that can be used  
12 in our performance assessment. We have not changed our  
13 performance assessment code yet, and as a result, we don't  
14 have any results to display what's the effect of these  
15 refinements, but I wanted you to be aware of the refinements  
16 that have taken place.

17           Now, pulling all this together, I want to talk  
18 about what I think are some of the key issues that we really  
19 need to deal with, and the first and very highest on my list  
20 is the EPA High-Level Waste Criteria, the fact that it has  
21 very, very strong regulatory and licensing implications that  
22 are associated with the legislation which is yet to be signed  
23 by the President, if I'm up to date. It has a lot of  
24 implications, and I think it's very important for those of us  
25 who are involved in the process to be involved in the

1 process.

2           If the National Academy is given the responsibility  
3 to carry out some dose-based recommendations to the EPA, I  
4 think it will be vitally important for us to be supplying  
5 appropriate technical input that says what implications does  
6 this have.

7           One of the steps we will be proceeding, then, on is  
8 to take this release of radioisotopes to the accessible  
9 environment and say, how do you now translate that into some  
10 dose calculations?

11           The second key issue here is the engineered barrier  
12 system design; borehole or drift emplacement. I think almost  
13 all of us continue to do modeling based on borehole. We will  
14 be changing that in the next few months to do drift  
15 emplacement kinds of calculations, since they seem to be the  
16 implied, although not the official design that's currently  
17 within DOE.

18           The questions of thermal load continue to be vital  
19 ones that everyone is considering. I'm not as convinced that  
20 it has a very strong implication with regard to performance  
21 assessment, but it does have a fairly strong implication with  
22 regard to unknowns.

23           The selection of a particular waste container--and  
24 I've put here with question marks, UCS, representing the  
25 universal container system--that, I think, has very important

1 implications for how the waste container might be put  
2 together. The universal container, for those of you who are  
3 not aware, is something that has been pushed rather strongly  
4 by the utilities as a thin-walled container that might  
5 contain up to 24 PWR fuel elements, which could be sealed by  
6 welding at the plant location at the time it is loaded, never  
7 to be unloaded again. So it would give you a one shot, let's  
8 put the stuff in and then let's keep it there forever. It  
9 has some strong economic and radiological dose implications  
10 with regard to operations that are very positive, as well as  
11 developing some sort of a standard.

12           It is recognized by the utilities there is not a  
13 single universal container that would suffice for this,  
14 because of various differences in sometimes size, but most  
15 often crane capacities. It's clear that not just one  
16 universal container system would suffice for all utilities.  
17 Nonetheless, the idea of standardization is important, and  
18 we've had some very significant early discussions with DOE  
19 which seem to be going very well regarding some  
20 standardization.

21           If one put the universal container system in there,  
22 that gives an additional barrier. One concept could be that  
23 what, of course, you have on the inside is the zircaloy  
24 barrier. Now you have a thin-walled universal container  
25 system, and presumably, you'd have an overpack which, for the

1 example of a corrosion-resistant or a corrosion-barrier type  
2 one, maybe of ductile cast iron, you'd now have a heavy  
3 material on the outside. So it gives you actually a triple  
4 layer of protection involved at the waste containers.

5           The concept of backfill materials is one that we  
6 have not included yet in our concepts. That design aspect is  
7 one that is being considered by the M&O, and it is one more  
8 modification that we will want to consider in our performance  
9 assessment.

10           Moving down one layer, some key source term issues,  
11 as I see them: The first and obvious one at the top of my  
12 list is solubility data. Actually, in many cases, the data  
13 is there, but the particular conditions under which it would  
14 take place, the solubilization would take place, is not very  
15 well known. That means that the water conditions that could  
16 exist at the time that solubilization takes place is probably  
17 a very important feature.

18           The spent fuel inventories, especially Carbon-14,  
19 continue to nag us, and I think when we ask detailed  
20 questions about especially Carbon-14 and how we know where it  
21 is, we find there's extremely limited data, and sometimes  
22 even extrapolations that have taken place in order to get us  
23 to the point where we seem to consider that 2 per cent is on  
24 the outside of the fuel, et cetera, et cetera. I'm not very  
25 confident that that particular set of data is a remarkably

1 good one.

2           I had alteration rates on this list. I think we  
3 heard some significant input of data yesterday regarding both  
4 alteration rates and solubilization. They also give me some  
5 pause, and a lot of the pause has to do with the effective  
6 way in which we integrate these results. On the one hand, I  
7 heard Bob Einziger talk about the alteration rates that take  
8 place in spent fuel and how important it is to look at actual  
9 spent fuel, not just uranium dioxide. And then we heard  
10 Walter Gray talk about the release that comes from his  
11 solubilization tests.

12           Now I, as a modelist, have a lot of difficulty  
13 taking the weight per unit area per unit time and somehow--  
14 for solubilization--and somehow translating that into a  
15 solubility term, because it was clear from yesterday's  
16 presentation that the unit area is how much grain boundaries  
17 there are, and yet, from the previous presentation, the grain  
18 boundaries are a function of time, and I don't know how to go  
19 over the whole repository and make some estimate as to how  
20 much grain boundary I have there, and whether it's a function  
21 of burnup, thermal history, et cetera.

22           So translating that basic data--which I consider to  
23 be valuable--into a meaningful source term for these overview  
24 models is still very much a challenge. It's not clear in my  
25 head how those steps are going to take place.

1           Retardation is certainly a very significant  
2 question here, and when people talk about colloidal aspects,  
3 the only difference I see is that you have a significant  
4 change in retardation if you have colloids. And so it's a  
5 simple change in our model to account for colloids. Just  
6 tell me which isotope you want to make as a colloid, and I'll  
7 change the retardation of it and that, in effect, takes care  
8 of it. Of course, the difficulty is identifying which  
9 material could be in colloidal, and that goes back to the  
10 first question here, which is not solubility data, but which  
11 is water chemistry, since the water chemistry will control  
12 the extent to which we have colloids that might be formed and  
13 that, of course, is the last item here, which is not meant to  
14 be last in importance.

15           There are a number of site uncertainties.  
16 Infiltration, what is it at the repository elevation? We  
17 have various estimates, but we do not find in our model that  
18 it's an extremely sensitive area. The degree of fracturing,  
19 spacing, sizes, and I think we'll probably hear more about  
20 that as the Ghost Dance Fault gets described, although not  
21 maybe in the detail that I'm talking about, but also the  
22 degree of fracturing is a function of temperature, and if we  
23 change the repository temperature here, that can influence  
24 the time dependency of spacing and sizes of fractures.

25           The coupling between the fracture and the matrix

1 flow is a very vital part of the site uncertainties;  
2 permeability of fractures and the extent to which they're  
3 connected; lateral flow distribution, the extent to which we  
4 have impermeable layers, which seems to be one of the  
5 positions that's being taken recently, that there are some  
6 significant impermeable layers which will influence  
7 significantly the amount of water that actually gets to the  
8 site elevation.

9           Continuing on performance assessment modeling  
10 issues, how can performance assessment models be validated?  
11 We can look at subsections with some models, and we can look  
12 at integrated systems. And to a very great extent, the best  
13 technique we have right now for validating these overview  
14 models is simply to compare one with another and see if there  
15 are inconsistencies. But I think that there would need to be  
16 stronger techniques that we develop for model validation as  
17 we proceed towards the licensing application.

18           Bounding or conservative calculations versus  
19 realistic or best measure calculations, I've already stated  
20 my preference, which is the latter, but we certainly do have  
21 bounding or conservative calculations. I'm always troubled  
22 by the fact that sometimes these bounding or conservative  
23 calculations can almost, in a multiplicative effect, have an  
24 undesired effect on the results.

25           There needs to be self-consistency. We need to

1 continually go back and look and make sure that we haven't  
2 violated any of the basic heat, mass, and water transport  
3 balances that need to be present in the system, and that they  
4 need to be appropriately coupled. It's very easy to couple  
5 things together and lose sense of, in a chemical engineering  
6 sense, the fact that there has to be a balance on each of  
7 these features.

8           Cell versus homogeneous modeling is a question at  
9 this stage. We are moving more and more, I think, towards  
10 homogeneous modeling.

11           The use of expert judgment is, in my mind,  
12 absolutely vital, and as a result of that, we have to explore  
13 the various ways in which expert judgment can be used  
14 effectively and defensively, so that we can use it  
15 effectively in getting the right results, but also use it in  
16 a defensible fashion so that when you come to licensing, you  
17 can show that expert judgment was used in an appropriate  
18 fashion for that particular purpose.

19           The issue of how you go from detailed models to  
20 overview performance assessment models is continually an  
21 important consideration. We've talked about transfer  
22 functions or, in some cases, just data tables that enable you  
23 to take detailed calculations, compress them down, and make  
24 use of those then in the overview performance assessment  
25 model. The level of details in the overview models is one

1 that we try and restrict as much as we can. The more detail,  
2 the less opportunity you have to really look at these  
3 sensitivities. So I'm in favor of less detail at this level.

4           Incorporating probabilistic and deterministic  
5 aspects is an important consideration, and these things have  
6 cost and schedule implications. Further, they can be used as  
7 a tool to look at cost and schedule implications that have to  
8 do with various sensitivities, and that's another area that  
9 we will be exploring in the near future.

10           So that completes the presentation I wanted to give  
11 to you, and I'm open for any questions.

12       DR. DOMENICO: Thank you very much, Bob.

13           Any questions from the Board or the consultants?

14       DR. GARISTO: Nava Garisto.

15           I wonder what your opinion is about the current  
16 limitations of analytical models in these kind of  
17 calculations now that computer resources become more  
18 available and much cheaper. Do you think that numerical  
19 calculations will provide more flexibility, especially if the  
20 design of the repository keeps changing?

21       MR. SHAW: I see numerical calculations as simply a way  
22 of doing the calculations that our theories say will be the  
23 important mechanisms and processes. I don't presently see  
24 that we're going to be moving, especially in overview  
25 performance assessments, to much in the way of numerical

1 calculations. In the more detailed calculations, I can see  
2 that that can be very useful.

3 DR. DOMENICO: Any other questions? Yes, John.

4 DR. CANTLON: Bob, your comment about looking at the  
5 universal cask concept and having the utilities seal it at  
6 the point of entry, in a sense, that would preclude looking  
7 more seriously at some of the buffer-filler options that  
8 might cut down oxidation on cladding and speeding up of  
9 solubility of the waste pellets. Has any of that gotten into  
10 your model thinking?

11 MR. SHAW: No, it hasn't, and what you say is true. It  
12 would mean that the filler, buffer material that would go  
13 inside such a container, that you don't have the option to do  
14 that. It does give you the option to put that between the  
15 overpack and the universal container, as well as on the  
16 outside of the overpack, but it would limit that option, that  
17 is true, I agree, and we haven't looked at that. Matter of  
18 fact, we don't even have in our model at this stage the  
19 effect of any filler material. I noted backfill, but filler  
20 material also is another aspect of that, too.

21 DR. CANTLON: Well, it would seem that looking at a  
22 buffer-filler in the rods and in the assemblies would  
23 stabilize the system and slow up, if that were a major oxygen  
24 cell, could behave very much the same way that you have a  
25 bentonite sump for water, preventing it getting into the

1 pack.

2 MR. SHAW: I agree. I could see, for example, iron  
3 filings being used as an oxygen absorber, yes.

4 DR. DOMENICO: Any questions from the staff?

5 DR. NORTH: I'd like to follow on with a question that  
6 gets into the issue of engineered barrier design and  
7 repository design. One of the things that I have learned  
8 from the meeting today and yesterday was the potential  
9 importance of what I'll call dependencies or inhomogeneities.  
10 That, for example, it may be that a fuel element, that is on  
11 the tail of the distribution in terms of some kinds of  
12 radioisotopes, may be more likely to fail through a mechanism  
13 such as gas pressure. Or another example is, we may have  
14 inhomogeneities with respect to the amount of flow in the wet  
15 drip mode and, as a result, I think we can see a number of  
16 scenarios for why failures in some areas of the repository or  
17 some canisters might be a good deal more likely than others.

18 Some of these we might be able to identify in  
19 advance, and some of these we probably can't. They will  
20 remain uncertain. But getting at this variability issue, set  
21 of variabilities, versus uncertainty, those things we can't  
22 learn about, certainly will be important in the modeling and  
23 to the extent that we can identify where failure is more  
24 likely, we might want to take that into account in terms of  
25 the design decisions.

1           As one example, if there are known ruptured fuel  
2 rods, it might be that in a situation where that is known to  
3 be the case, there, for sure, you want to use a filler  
4 material and you might decide for economic reasons that where  
5 there is no indication of damage to the fuel rod, you choose  
6 not to do that.

7           So this seems to me to open up another class of  
8 sensitivity questions, and another area in which one might  
9 want to look very carefully at the aggregate performance  
10 assessment models, as opposed to the detailed models of  
11 mechanism, and I wonder to what extent you've thought about  
12 that or would like to comment further.

13         MR. SHAW: Well, to go back to your original premise,  
14 that there can be special circumstances where you get  
15 increased possibility of rupture, first of all, there are  
16 inspections, of course, that are carried out at the plant  
17 sites to determine the extent of spent fuel degradation and,  
18 in particular, to look at where there have been fuel  
19 failures. And in most cases, either those assemblies--or in  
20 some cases, those rods--are removed, and we've gone from the  
21 point of just sampling an assembly in order to identify  
22 whether there's any radioisotopes being released, to the  
23 point of actually identifying which rod that is being  
24 released from, and that technique that's used is to identify  
25 where water has actually been absorbed inside the rod, and

1

2 using that as the technique to identify the rods.

3           So there will be cases, certainly, now, where rods  
4 are being removed from fuel assemblies where they are able to  
5 disassemble such fuel assemblies, and you will have a  
6 collection of rods, or maybe an assembly that has a  
7 collection of rods that have failed. So there is reason to  
8 consider that that might occur.

9           Secondly, the question of internal pressure and  
10 maybe an excess of radioisotopes that would be present as a  
11 result of operation would certainly have to do with burnup,  
12 and the more burnup you have, the more you have both more  
13 heat generation and more fission product inventory. And  
14 certainly, all of the utilities have the capability of  
15 calculating burnup on a rod-by-rod basis, and so therefore,  
16 that information should be available once one knows what's in  
17 a particular canister.

18           Now, it might be possible to then begin thinking  
19 about how would one use a filler material in maybe selected  
20 kinds of assemblies, but it's also important to remember that  
21 if you have 24 PWR bundles, roughly 250 rods per bundle in a  
22 particular canister, we're talking on the order of 6,000 rods  
23 that will be in a particular assembly, and even with .01 per  
24 cent, you're talking about at least a handful of rods that  
25 will have failed within a particular collection like that.

1 So one could look for anomalies where there were  
2 significantly more failures than that, or situations where  
3 the burnup was decidedly higher in a particular container  
4 than others, and that might give you reason to say, well,  
5 let's consider how we might design that system so that is  
6 more effectively buffered with the loss of integrity.

7 I can see that, you know, process that we might  
8 well follow along on.

9 DR. DOMENICO: Any further Board questions? Staff?  
10 Bill?

11 DR. BARNARD: Bill Barnard, Board Staff.

12 Bob, one of your recent refinements that you  
13 discussed was a new scenario, temperature scenario delta,  
14 which involves high temperatures for over--above boiling  
15 temperatures for greater than a thousand years, or up to a  
16 thousand--10,000, I'm sorry.

17 In a subsequent slide, you stated that you didn't  
18 think thermal load would have much effect on the CCDF. Now,  
19 was that based on the runs that you did for alpha, beta, and  
20 gamma?

21 MR. SHAW: Yes, it is.

22 DR. BARNARD: Do you have any feeling for what sort of  
23 results will come out of the delta?

24 MR. SHAW: I'd prefer not to try and pre-judge that.

25 The calculations get fairly complicated at times, and I think

1 it's pretty difficult to estimate what's going to happen as a  
2 result of that, so I'd like to await that for the next  
3 presentation when we're ready to discuss those results.

4 DR. BARNARD: But you still don't think that thermal  
5 load has much effect probably relative to solubilities, is  
6 that it?

7 MR. SHAW: Well, first of all, of course, my judgment  
8 comes from CCDF's, and it precludes--it may be precluded, you  
9 know, based on the fact that we may be looking at dose, and  
10 if dose turns out to be a very important feature, it may be  
11 that keeping container integrity for a longer period of time  
12 becomes a much more vital issue.

13 I think the whole scenario is in a transitional  
14 stage right now, and we're going to have a different set of  
15 limits that we have to look at, and so some of those--all  
16 those conclusions are based on CCDF's and the EPA limit, and  
17 so I think we can't throw out any of these things right now  
18 on the surmise that we're going to have a whole different set  
19 of standards to compare with.

20 DR. DOMENICO: Anything further from staff? We have  
21 time, possibly, for one question from the audience.

22 MR. CURTIS: Dave Curtis from Los Alamos.

23 I only bring this up because you did, but the  
24 concept of validation is really important, I think, and I  
25 don't mean validation in the sense that your computer code

1 works the way you think it works, I mean validation in the  
2 sense that you're going to have to convince somebody that  
3 this has some connection with reality.

4           Could you comment on how you think that case might  
5 effectively be made?

6           MR. SHAW: What I can comment on is that we've been  
7 doing a lot of thinking about how you do that. How do you  
8 take the physical processes, which is what you're  
9 emphasizing, and show that the computer model that you have  
10 actually verifies the physical process?

11           I think it's much easier to do on a sub-model  
12 basis, where you look at, for example, the hydrology, and you  
13 try and say: Is the hydrology model that we've developed for  
14 unsaturated environment, does it have anything to do with  
15 what's going on at Yucca Mountain?

16           And I think as we get into Yucca Mountain and get  
17 more data, as we do large block tests and some other features  
18 of that nature, we begin to get to the point where we can  
19 validate a little better whether our models are approaching  
20 the reality, at least for those sub-groups of tests. But I  
21 agree with your first point, I think it's a very difficult  
22 and challenging process for us to be able to validate this,  
23 because there is inevitably very limited data over very long  
24 times of predictions, and it is a challenge. I don't have  
25 any nice answers for it.

1           MR. CURTIS:  And the reason I bring this up, it seems to  
2 me that's a subject which seems to get lost in most of these  
3 presentations.  We feel comfortable dealing with the  
4 technical issues, but the "validation" issues just seem to  
5 get lost and I'm not sure whether they just get lost in these  
6 meetings, or if they're getting lost in the whole process.

7           MR. SHAW:  Well, I think partly it got lost--I would  
8 hesitate to use the word "lost."  That's why I keep it up  
9 there.  But I think for the last year or two we've been at  
10 the stages of putting together the first performance  
11 assessments and coming up with these results, and then  
12 looking at these results and saying, do they make any sense?

13                   And when we begin to see different results--I'm  
14 sorry--different assessments, models that have different  
15 bases or at least different calculational techniques, albeit  
16 that they go back to very much the same physical processes  
17 and estimates, when we come out with those and say they're  
18 not too much different, it gives us a first level of  
19 confidence that now says, what's the next step to go to in  
20 terms of validation?

21           MR. CURTIS:  I don't agree with that because basically  
22 these things--

23           DR. DOMENICO:  Gentlemen, we must go forward here.  We  
24 have the questions, but let's not have a debate on the floor,  
25 please.

1           Thank you much, Bob.

2

3           The fourth presentation on source term comes from  
4 the Nuclear Regulatory Commission. My agenda says Dick  
5 Codell and Tae Ahn. I don't know if we're going to have one  
6 or two presenters here, but I guess we'll find out; right,  
7 Dick?

8           DR. CODELL: I'm Dick Codell. In the interest of time,  
9 I'll be making the presentation, but Tae Ahn is sitting at  
10 the table here. John Walton is in the audience, and Ginny  
11 Colten-Bradley, who is another person here from NRC. I may  
12 be deflecting some of the questions because I'm not sure I'll  
13 be doing justice to the entire source term matter.

14           Let me state first that I appreciate being last on  
15 the program because it gives me a chance to make some  
16 editorial comments on the other presenters.

17           (Laughter.)

18           DR. CODELL: Let me say a little bit about NRC's role.  
19 First of all, we can't hope to duplicate the vast talent that  
20 DOE has assembled for this project, but we hope we can keep  
21 them honest. Also, it gives us an opportunity to participate  
22 in this very interesting project of coming up with source  
23 term models, because I think we'll have to have these skills  
24 honed in order to do a good job as regulators.

25           In my presentation today, I'll be going through the

1 following: First, the temperature model, looking at the  
2 temperature in the near field of the source term engineered  
3 barrier; waste package failure model; liquid radionuclide  
4 release; a Carbon-14 gaseous model which is different from  
5 most of the others I've seen; some discussion of kinetic  
6 effects, which I feel have been not treated properly in most  
7 of the models; and a short discussion of disruptive releases  
8 from the source term. Finally, I'll finish up with support  
9 work going on at NRC and at the Center for Nuclear Waste  
10 Regulatory Analyses supporting the source term.

11           The canister temperature model is simply a semi-  
12 analytical model that treats only conduction in a uniform  
13 medium, but it looks at each of the individual--some 30,000  
14 canisters--in the background of the geothermal gradient and  
15 the impact of the earth's surface, and heat from the other  
16 waste panels. The heat load can also vary with time and  
17 space, so you can take into account different fuel loadings  
18 and sequence of loadings. At the iterative performance  
19 assessment, Phase 2, which we're currently involved in, it's  
20 mainly used for looking at canister failure, and also in the  
21 Carbon-14 model, which is temperature dependent, but not in  
22 the other releases.

23           The canisters in our representation of Yucca  
24 Mountain are arranged in about 30,000 spent fuel canisters--  
25 we're only looking at fuel at the present time--in 17 waste

1 panels arranged in drifts in the mountain, and each one of  
2 these can have a different heat loading, and does in our  
3 model.

4           Now, in our performance assessment, we're somewhat  
5 limited to how fine a resolution we can have in terms of the  
6 flow and transport model, so actually, it's arranged into  
7 seven sub-areas, A, B, C, D, E, F and G, which are whole  
8 numbers of panels, and these, in turn, go as the source term  
9 inputs to the transport models in our overall performance  
10 assessment. So these are seven sub-areas or cells, as we  
11 call them.

12           Now, we go through with the temperature  
13 calculations and come up with curves that are similar to  
14 these, which show at different points in time--each line  
15 being a different time, 500 through 3,000 years--the number  
16 of canisters whose temperature is above or below this  
17 temperature of 96°, which we take as a representative  
18 boiling point. And when a canister falls below that  
19 temperature, we assume that it instantaneously is wetted, not  
20 taking into account the time that it probably would take to  
21 re-wet the canister after it starts to cool down, and at this  
22 point we start invoking the canister corrosion models for  
23 looking at corrosion failures.

24           Now, that temperature I had up there was the  
25 temperature of the skin of the canisters. The temperature

1 inside the canisters, which we need for the Carbon-14 source  
2 term model, is an empirical correlation of measured fuel  
3 temperatures versus the skin temperature and time, and this  
4 temperature is added to the skin temperature to get the fuel  
5 temperature.

6           The canister corrosion models. We consider general  
7 corrosion, crevice corrosion, and pitting corrosion. John  
8 Walton may have to answer some of these questions if I don't  
9 make the presentation right, but the model considers the  
10 corrosion potential similar to this curve for the crevice and  
11 pitting corrosion; that is, with time, the corrosion  
12 potential--which is this heavy line--increases up to a point  
13 until it passes a point at which pit initiation begins, and  
14 from that point on you would have pit corrosion or crevice  
15 corrosion until it drops below a repassivation potential, and  
16 then corrosion in the pit stops, but you still have general  
17 corrosion of the background material. The models in the  
18 source term model act this way, but they are empirical.  
19 They're not too mechanistic.

20           There are other modes of canister corrosion--I'm  
21 sorry--canister failure considered in the source term model.  
22 There is buckling, where we're looking at the SCP design  
23 with 304L stainless. It's a long cylinder approximation for  
24 buckling, and the thickness is allowed to decrease generally  
25 by corrosion. We don't consider an air gap, nor is there

1 stiffening.

2           Furthermore, in addition to buckling failures, we  
3 consider initial defective waste canisters which are presumed  
4 to fail shortly after they're emplaced, for no good reason;  
5 and finally, there is disruptive scenarios, where we look at  
6 seismic failure, also coupled with the buckling model;  
7 volcanism, where we're looking at intrusive or extrusive  
8 volcanism of the dikes or cones through the middle of the  
9 repository; and finally, human intrusion through drilling.

10           Once the canister is assumed to fail, we start  
11 considering release rate from a canister, and the source term  
12 model, SOTEC--which it's called--we look at dissolved and  
13 colloidal releases by advection; that is, flowing water goes  
14 through the canister; diffusion through the rock; and we  
15 also, in considering the releases of dissolved or waterborne  
16 radionuclides, have some consideration of kinetic effects as  
17 in the disintegration of the uranium matrix.

18           We also have a Carbon-14 gaseous release model,  
19 which looks at the inventories in the metal, cladding, grain  
20 and gap, and the fuel itself, and I'll be spending some time  
21 on that.

22           Our dissolved model borrows heavily from former  
23 DOE-sponsored efforts on source term. We consider a vertical  
24 canister in this cartoon, but where we have a fuel element--  
25 fuel rod which is considered to have no protection from

1 cladding. We do not consider that in Phase 2. The water  
2 will flow in through a hole in the top by dripping, will  
3 either fill up the canister to a certain level and then flow  
4 out again, or run down the side of the fuel rods, dissolving  
5 the fuel as it goes.

6           By varying the volume of the canister that we're  
7 allowed to fill up here, and the fraction of the fuel that  
8 can be wetted by the dripping, and the flow rate, we can get  
9 various combinations that DOE's explored in the past for  
10 dissolution. We also consider that if the radionuclide is  
11 solubility-limited, that it may first be released from the  
12 disintegrating fuel and then go into a released, but  
13 undissolved inventory, which would be released, perhaps,  
14 later as the source term from the fuel itself diminishes and  
15 if the water continues to flow through and out of the  
16 canister. That's the advective part.

17           I might point out here that the amount of water  
18 entering the canister is a great unknown to everyone in this  
19 room, I'm sure. How we're treating it is not very  
20 satisfactory, either, but we're getting it from a coupled  
21 unsaturated flow model, where we're looking at separate flows  
22 through fractures and matrix coupled together, and the amount  
23 of water that flows through the fractures, we're taking a  
24 portion of that and diverting it into the canisters. So  
25 that's where our flow rate through the canisters comes from.

1            Now, to the advective model, we add the potential  
2 diffusion, and this is our liquid diffusion model. We now  
3 consider the canister as a sphere, for mathematical  
4 simplicity, and we assume that at the surface of the  
5 canister, the concentration is set by the concentration in  
6 the total canister. This differs from some other DOE  
7 approaches where they looked at this concentration as a fixed  
8 concentration, also for mathematical simplicity, as being set  
9 at some sort of a solubility limit. This is an improvement  
10 in that it allows the concentration to vary with time, but  
11 this had to be solved with a numerical model rather than an  
12 analytical model.

13            We look at diffusion through three rock zones.  
14 First is the air gap, which we assume to be partially filled  
15 with tuff rubble, and then there's a damaged rock zone, and  
16 then the intact rock zone. The boundary condition set on  
17 this is that at some arbitrary distance, say, ten meters,  
18 concentration is zero. The concentration gradient then drops  
19 between the canister concentration and zero, which we feel is  
20 a conservative assumption, of which there are many in this  
21 model. And that flux that comes from the diffusion model is  
22 simply added to the advection model.

23            Now, this is a point where I want to start  
24 editorializing a little. We're taking into account releases  
25 of plutonium and americium and other actinides, probably much

1 more so than the other participants here today, although I'm  
2 glad to see that Bob Shaw did recognize wide variations in  
3 these concentration solubility limits that I think capture  
4 some of our concerns.

5           We feel that some of the other contributors have,  
6 in the past, given short shrift to the potential of plutonium  
7 and americium. If you look at the dose potential as some  
8 sort of a measure based on what EPA allows you to be  
9 released, the quantity present, the half life, these two  
10 elements add up to over 99 per cent of the potential dose,  
11 and so we're reluctant to ignore them.

12           Even though in some ways it's possible to calculate  
13 very low solubilities for these things, and also measure  
14 experimentally very low solubilities, there are other factors  
15 that we ought to maybe address. One of these is the kinetic  
16 effects, where the way in which these elements are released  
17 from the uranium fuel would cause various complexes or  
18 colloids, other strange things to form that could be much  
19 greater than we're allowing in some of the modeling studies.

20           Now, we don't, at this Phase 2 study, have any  
21 sophisticated modeling built into our performance assessment,  
22 but we're taking a wide range of plutonium solubilities to  
23 represent these great unknowns, and between  $10^{-5}$  and  $10^{-9}$  M,  
24 which I think is appreciably larger than others have used.

25           We've done some speciation calculations at 25°C

1 that indicate that this is a reasonable range, but haven't  
2 been so successful at 85%. Ginny Colten-Bradley may be able  
3 to answer some more on that.

4           Now, getting further on, getting further over my  
5 head, I should say, in this topic, I'd like to talk about Tae  
6 Ahn's subject, looking at what possibly could lead to fast  
7 releases. First of all, we suspect if there were fast  
8 releases, they could be colloids, either real colloids or  
9 pseudo colloids; that is, the radio elements attached to  
10 naturally-occurring silicate or other colloids in the water,  
11 which have been observed in Yucca Mountain water.

12           One of the mechanisms for the growth of colloids is  
13 supersaturation of, say, the plutonium as the uranium  
14 oxidizes and releases. It releases at a rate much faster  
15 than the water could dissolve these other things, and so they  
16 would be supersaturated and you could start growing colloids  
17 from this supersaturation.

18           Furthermore, you could get speciation into various  
19 states of the plutonium with different charges, some of which  
20 may be organic species that would be formed from naturally-  
21 occurring chemicals or even organics that ended up in the  
22 water from human means.

23           The surface area of the spent fuel is an important  
24 factor in these. As the fuel dissolves, the surface area is  
25 likely to increase, both from the dissolution and exposure of

1 grain boundaries, or the spallation of the fuel. Increasing  
2 surface area according to Dr. Ahn's model, would lead to  
3 higher rates of the release of colloids.

4           Furthermore, the effects of radiation and stress  
5 would lead to formation of colloids. Stress could come about  
6 because of the change in volume as the uranium oxidizes. In  
7 certain states, it either oxidizes or shrinks, depending on  
8 its oxidation state, and this would lead to stress and  
9 spallation of the fuel. Dr. Ahn also describes microbial  
10 attack as a possibility in the oxidizing, warm environment of  
11 Yucca Mountain. This might be a consideration in both  
12 corrosion of the canisters and of the fuel.

13           There is much evidence for kinetic factors being  
14 important in uranium. There is natural experiments in the  
15 field with uranium mines. There is a lot of evidence for  
16 multi-phase formation as the uranium in these mines oxidizes.  
17 There are 160-some species of uranyl compounds, probably  
18 many more. You can see 50 to 150 of these in the paragenesis  
19 of secondary phases in some of these mines.

20           Some of these phases are unstable. One of the  
21 reasons that it could be unstable is from the radiation in  
22 the spent fuel itself; also, microbial attack. These don't  
23 generally form protective layers, so they likely lead to  
24 further paragenesis to other phases.

25           Finally, there is the environmental changes which

1 we observed in nature at uranium mines, wetting and drying  
2 cycles, temperature changes, and we're certainly going to  
3 have environmental changes over the 10,000 years at Yucca  
4 Mountain, both in terms of wetness and temperature.

5           I'd next like to move on to the Carbon-14 source  
6 term model, which I feel is one of the contributions NRC's  
7 made to the source term issue. We look at the inventories of  
8 Carbon-14 in cladding oxide and crud--this is the outer  
9 boundary of the cladding--the grain boundary and cladding  
10 gap, the Carbon-14 that's inside of the zircaloy that is not  
11 readily accessible, and then the Carbon-14 in the fuel itself  
12 that can get out as the fuel oxidizes. The model includes  
13 those four mechanisms.

14           I'll put up this familiar picture of a fuel rod,  
15 just to refresh your memories of where these inventories are;  
16 the crud on the outside and the metal itself, the gap, the  
17 fractures in the inner grain boundaries, and the fuel matrix  
18 itself.

19           The next slide shows the inventories which are  
20 similar to what Rich Van Konynenburg had put up, and we're  
21 assuming that, on the average, there's a total of 1.24 Curies  
22 per metric ton of carbon distributed between the various  
23 compartments of the fuel.

24           We assume that the carbon is in a reduced state  
25 initially and has to be oxidized before it can get out. The

1 Carbon-14 in the fuel gets out as the fuel oxidizes. I'll  
2 get into that more later. The carbon dioxide diffuses out  
3 through the fuel as it oxidizes. We assume that it's  
4 released quickly from grain boundaries, cladding/fuel gap,  
5 and initial zirconium oxide. We have some reasonable data to  
6 confirm this quick release fraction of about a total of 2%  
7 per cent, and there are minor releases from oxidation of the  
8 cladding, and there are also reasonable data on that based on  
9 many years of experience of zirconium in reactor fuel.

10           The model for the diffusion of Carbon-14 out of the  
11 outside zirconium oxide is based on some experimental data  
12 collected at PNL, and what this table shows is that for any  
13 reasonable range of temperatures, the amount of time that it  
14 would take to diffuse virtually all the Carbon-14 out of the  
15 oxide is short, even compared to 10,000 years. All of these  
16 times over this range and two different assumptions of  
17 activation energy show that we'd expect it virtually all to  
18 get out in 10,000 years. That was data collected by Smith  
19 and Baldwin.

20           Now, the fuel oxidation model, since most of the  
21 Carbon-14 we're worried about is in the fuel itself, we  
22 assume that there is no protection of the cladding and, of  
23 course, no oxidation can occur until the canister fails.  
24 Oxygen diffuses through two layers in our model. The outer  
25 layer represents diffusion through the grain boundaries of

1 the fuel. The inner layer represents diffusion through the  
2 oxidized fuel layer; that is, the layer of the fuel grain  
3 that is starting to oxidize. We assume that that oxide is  
4  $U_3O_7$  stoichiometrically, because we need to know how much  
5 oxygen it takes to convert the fuel. So it takes, for each  
6 half mole of oxygen, you convert three moles of uranium  
7 dioxide fuel.

8           We've assumed that the oxygen concentration is zero  
9 at the point that the fuel is oxidizing, and that the oxygen  
10 profiles in the fuel are at steady state. This can be  
11 illustrated on the next figure. I think I'll skip one of  
12 these here. This figure here.

13           We have the oxygen available at the outer boundary  
14 of the grain boundary layer, and then the oxygen's diffusing  
15 through the grain boundary layer, which has a rather high  
16 diffusion coefficient, and then further diffusing for the  
17 oxide layer, the  $U_3O_7$  layer, to the  $UO_2$ , unoxidized  $UO_2$  fuel.

18           As the front passes, we assume that the Carbon-14  
19 in the fuel oxidizes, and then diffuses out through these two  
20 layers, the same two layers that the oxygen diffuses in. To  
21 make this model viable, we have to assume a certain size for  
22 the grain and the outer layer, and pick coefficients that  
23 represent the diffusion.

24           This assumption, incidentally, about the carbon  
25 oxidizing is difficult to substantiate, but

1 thermodynamically, the carbon is less stable than the  
2 uranium, and it does appear that it would oxidize the carbon  
3 as soon as it comes into contact with the oxygen; that is, at  
4 the time that the front reaches the fuel.

5           So in order to identify the model, the parameters,  
6 we used data collected almost exclusively at PNL by Bob  
7 Einziger & company, that looked at the weight gain of the  
8 fuel that's exposed to air between--and also in dry bath  
9 experiments that Bob described yesterday--between 110° and  
10 250° C.

11           Even though we expect a wide range in sizes of the  
12 particles, we took the grain diameter as 20 microns, and the  
13 outer layer diameter as 2 mm, representing the approximate  
14 size of a cracked up fuel grain inside a fuel rod. We also,  
15 in addition to the weight gain data from these two  
16 experiments, looked at ceramigraphic data, where they sliced  
17 the pieces together and physically observed the size of the  
18 oxide layer growing on the fuel grains.

19           We picked activation energies and diffusion  
20 coefficients based on the best fit from eight temperature  
21 ranges between 110° and 250°, but there are little direct  
22 data on Carbon-14 releases. This is all inferred from the  
23 oxidation of the uranium fuel only.

24           So this next slide is not in the package, but shows

1 that we came up with a single set of values for this simple  
2 model that adequately fit the data, and the next slide, which  
3 is in your package, shows the fit we got for four of the  
4 temperature ranges that shows us pretty reasonable fit, I  
5 would say, starting here at the lowest temperature, 109°F,  
6 130°F. This, incidentally, is conversion versus time and  
7 hours, conversion of the fuel from the unoxidized to the  
8 fully oxidized. This is 225°F and this is 250°F, so we're  
9 reasonably happy with that model, and that is the model that  
10 goes into looking at the release rates of Carbon-14.

11           Just as an illustrative example, we looked at two  
12 cases here. We assumed 66 randomly-spaced canisters that  
13 fail when their temperature drops below 96°F, and then has a  
14 failure--I should say that start to fail when the temperature  
15 drops below 96°F, and then has a lifetime beyond that of  
16 1,000 years  $\times$  300 years. We see that the release rates from  
17 the engineered barrier only exceed the EPA limit, and that  
18 most of it is due to the fuel, a little bit from the prompt  
19 release fraction, virtually none of the Carbon-14 from the  
20 oxidation of the zirconium.

21           Now, if you have a failure that instead of 1,000  
22 years  $\times$  300, 200 years  $\times$  100, the canisters would fail when  
23 they're much hotter, and the rate expressions are  
24 temperature-dependent, so we'd see a much greater release

1 rate mainly from the fuel. So temperature is dependent, and  
2 the canister lifetime is dependent in the Carbon-14 gaseous  
3 release model.

4           I might also point out an important point, that you  
5 can have the Carbon-14 release irrespective of any water. So  
6 this is one of the radionuclides that could be released  
7 before you get any water into the canisters.

8           I think I will skip the next two slides, other than  
9 to say that we're improving the model to take into account  
10 transient oxidation effects. Some of the coefficients may be  
11 off because we're assuming that the model's steady state, and  
12 in some of the data you see some effects that are transient  
13 with the oxidation weight gain, and this might lead to some  
14 errors in the application of the model. Also, we hope to  
15 look at the increase in surface area of the fuel with time at  
16 some later stage.

17           Briefly, the disruptive release cases, we look at  
18 the intrusive volcanism with a dike between 1,000 to 4,000  
19 meters long, one to ten meters wide; also extrusive  
20 volcanism, a cinder cone between 25 and 100 meters radius;  
21 and drilling that either brings up a portion of the contents  
22 of a waste package, or if it doesn't hit the waste package  
23 but the canister has started to leak already, brings up  
24 contaminated rock.

25           In the intrusive volcanism case, we look either at

1 bringing the contents of a waste package to the surface--  
2 which we consider unlikely--or the volatilization of some of  
3 the radionuclides in the waste. For those volatile  
4 radionuclides, we considered that iodine, oxides with  
5 selenium and technetium and cesium could be volatile, though  
6 there's some question about this--and also Carbon-14, of  
7 course. This is the ratio of what is in the waste as  
8 compared to what you're allowed to release under current EPA  
9 standards, so there's a great deal of cesium and not too much  
10 of anything else. Technetium is the next largest.

11           So according to some of the data I've laid my hands  
12 on, some of these things are, indeed, volatile. Whether they  
13 will get out into the environment is another thing, because  
14 they might very well be trapped in the liquid water in the  
15 rock and not actually get out to the atmosphere, but could be  
16 presented as liquid source terms to be transported down into  
17 the groundwater.

18           But the upshot of the calculations is that there is  
19 not very much alarm from the volatilization, even in about  
20 the worst case of a 4,000 meter long dike that's 10 meters  
21 wide and has a effective heating width of 100 meters of the  
22 rock, you would not volatilize more than 10 per cent of what  
23 you'd be allowed to be released of those things, according to  
24 the EPA standard. And also, the probabilities would be quite  
25 low for those things happening in the first place.

1           To begin to wrap up here, I think that our biggest  
2 information needs are on this slide. First of all, the  
3 integrity of the canister; are our corrosion models and our  
4 buckling models valid? I think we have got a long way to go.  
5 Furthermore, we don't even have a final design.

6           How does water actually get into the canister?  
7 It's hard to visualize how that would actually happen. I  
8 think we need modeling and physical experiments to get a  
9 handle on that. I think some of the modeling experiments of  
10 Tom Buscheck show that we're likely to have large areas of  
11 dry rock and long periods of saturation and re-wetting, but  
12 also the possibility of water being driven off one canister  
13 onto a cooler one, and I think we'd dearly like to get some  
14 good numbers to plug into the performance assessment  
15 modeling.

16           How does the water interact with the fuel? Will it  
17 drip onto the fuel? What will actually happen? I think we  
18 have only a few experiments. I was very glad to see Dr.  
19 Bates' results on the glass dissolution, where they were  
20 dripping water on the glass, and a very recent paper where  
21 they were dripping it onto uranium dioxide at 90°C to try to  
22 get a handle on what actually happens when water drips on the  
23 fuel.

24           I'm a little concerned that what I've seen with all  
25 of the uranium species that are out there, whether we'll ever

1 be able to use modeling calculations to come up with  
2 syntheses of release rates from the canisters, and we may  
3 have to rely on empirical observations like that.

4           Does cladding offer protection? We're not taking  
5 any credit for it, but it's, as we all know, very corrosion-  
6 resistant and maybe we should take credit for it.

7           Are kinetic effects important? Will colloids form?  
8 Colloids, potentially, of things like plutonium could cause  
9 a lot of havoc. They could also be transported long  
10 distances in the rock and fractures, or they could be  
11 filtered out. I think there's a lot less known about those.

12           In conclusion, the NRC's model, SOTEC, includes  
13 waste package failure, releases of dissolved radionuclides.  
14 We treat colloids as if they're actually soluble, but  
15 extended the range of solubility of some of the radio  
16 elements to take that into account. We have a gaseous  
17 release model for Carbon-14, and we include codes for other  
18 gaseous radionuclides, volcanic intrusions, and drilling.

19           Finally, I'll put up a short list of some of the  
20 work going on at NRC and the Center for Nuclear Waste  
21 Regulatory Analyses, which support the source term. There's  
22 a detailed source term model that's being developed, called  
23 EPSPAC, of which SOTEC is a derivative. There is quite a bit  
24 of work going on in looking at natural analogs; Alligator  
25 Rivers, Pena Blanca, Santorini, Cigar Lakes, and Oklo, and a

1 number of NRC and CNWRA scientists take part in those.

2           Tae Ahn and others are looking at kinetic effects  
3 of fuel dissolution. There is some work going on at the  
4 Center on thermodynamic properties of actinides in high-  
5 temperature solutions, and finally, there is some work going  
6 on in metallic phases in spent fuel, which I'm talking about  
7 the so-called five metal alloys, which may include  
8 technetium. If technetium's important, these things are very  
9 insoluble and may ultimately lead to reduced rates of  
10 technetium release in our performance assessment models.

11           Thanks. I'll like to answer any question.

12       DR. DOMENICO: Questions from the Board? Staff?

13           At this time I'd like to go forward. We're running  
14 a little behind, but before we--I'd like to depart from the  
15 agenda for a minute, and maybe John Bartlett would like to  
16 introduce the Under-Secretary to us.

17       MR. BARTLETT: Thank you very much, Pat.

18           I'm grateful for the opportunity here today to  
19 introduce to all of you, to the Board and those others in  
20 attendance, Dr. Hugo Pomrehn, the new Under-Secretary of  
21 Energy.

22           (Appause.)

23       MR. BARTLETT: Dr. Pomrehn brings to his  
24 responsibilities a wealth of great technical and management  
25 experience. He has over a 25-year career experience with

1 Bechtel Corporation in designing and running nuclear power  
2 reactors. He has solid professional experience in his thesis  
3 work in probabilistic risk assessment, and I think he's a  
4 very valuable addition to the Department in his oversight of  
5 this program, and I look forward to it and I hope you do,  
6 too. Thank you for the opportunity.

7 DR. DOMENICO: Thank you very much, John.

8 Returning to the agenda, it's time now to--well, as  
9 we sit here, we're going to have some overviews by our two  
10 consultants, and then followed by an open discussion, which  
11 should be at least a half an hour, and then some concluding  
12 remarks on the source term sessions by Dr. North.

13 So Mick Apted from Intera Information Technologies  
14 will give us a fifteen-minute presentation on his views of  
15 what he's heard here in the last few days.

16 DR. APTED: For those who don't know me, I'm Mick Apted  
17 with the other Intera, which is different than the Intera  
18 that's currently involved with the M&O, and if you want to  
19 know more about that story, I'm available for a few beers  
20 over lunch.

21 It's difficult in a sort of overview and review  
22 role, not to end up sounding an awful lot like a scold, and  
23 you shouldn't do this, you shouldn't do that, and I will get  
24 to that in a little bit, I think, but first I guess I'd  
25 rather be a gossip a little bit, and we're going to gossip a

1 little bit about what's going on internationally in the area  
2 of source term modeling of near-field performance assessment,  
3 because I think the Board should probably be aware of this.  
4 The DOE and NRC are aware of what's been going on, so for the  
5 first two view graphs here, just sort of a simple summary of  
6 some recent events.

7           When one looks at, internationally, what's going on  
8 in the area of performance assessment for geologic disposal  
9 of waste, performance assessment is often resolved into--boy,  
10 that slide is awful, but anyway, into far-field and near-  
11 field performance assessment, and we also sometimes see  
12 biosphere being an important component in performance  
13 assessment.

14           We've done a preliminary review, and by "we," I  
15 mean myself and Dr. Kjell Andersson, who was formerly of the  
16 SKI regulatory group in Sweden, and we started looking at the  
17 various total system performance assessment reports that have  
18 been done by a variety of international organizations; the  
19 SKI, SKB are the two groups in Sweden, TVO in Finland, here  
20 we have the PACE-90, the WISP report from the National  
21 Academy of Sciences back in '83, the PHASE 1 report from the  
22 NRC, PAR report done by PNC in Japan, the Kristallin work  
23 done by Nagra in Switzerland, and this environmental impact  
24 work which is in draft from by the AECL.

25           So we looked at them in a very cursory, sort of

1 overview way to evaluate what was being done in terms of  
2 near-field performance assessment, what was the role of the  
3 near field, and there is a considerable bit of writing behind  
4 this, so this is a summary, but in our summary, the role of  
5 the near field is very high in most organizations and in most  
6 reports. There are a variety of reasons for this that we  
7 really can't go into today fully, but a few years ago I made  
8 a presentation about the near-field PA being the little  
9 brother of performance assessment. We're often told to go  
10 over and stand in a corner because it's not really a very  
11 dominant part of the system.

12           What we're finding is more and more the idea of the  
13 near-field performance assessment is dominating the  
14 international scene, partly from an ability to achieve a  
15 higher degree of predictive reliability from these, what the  
16 Scots call the "robust, massive redundant barriers of the  
17 near field," and so I commend, I think at least some of the  
18 drum beats behind the scenes I hear within the U.S. program,  
19 that some of this message is, I think, coming in to them.

20           The argument here is not to eliminate the far  
21 field. I'm not saying that the far field is flawed or we  
22 have to compensate for the far field, but it's very much into  
23 this concept of multiply redundant barriers, that we're de-  
24 coupling the performance of an engineered part of the system,  
25 which may have an adequate performance from itself, and maybe

1 have a certain degree of high reliability, from a far-field  
2 part of the system, which may have a tremendous isolation  
3 capacity, but may have a certain higher degree of uncertainty  
4 about that performance.

5           And so, it's not one or the other, but what we're  
6 seeing is that certainly in most countries, there's a  
7 considerable emphasis on evaluating, taking credit, and  
8 understanding the near-field performance. It looks to me  
9 like DOE's possibly getting their feet on that road, also,  
10 and that's, I think, to be commended. It is somewhat  
11 disheartening, sometimes, to see still the justification for  
12 near-field budgets, and so on, based on site suitability and  
13 exploratory shaft facility. Those are important, but the  
14 near-field performance is important in its own right, and  
15 probably that ought to be first and foremost in terms of  
16 trying to prioritize the work that's going to be done, in at  
17 least my opinion.

18           What I wanted to say as a follow-on from this  
19 review that Kjell Andersson and I have done, the Nuclear  
20 Energy Agency in Paris has endorsed and is coordinating with  
21 us a review of all the current work that's being done on  
22 source term modeling everywhere; everywhere from Korea,  
23 Japan, U.S., Canada, all of Europe. We're all putting this  
24 together for a large review. That is a presentation in  
25 itself. I'm not going to make that today. These are just

1 some of the things in terms of the who, what, and where and  
2 why aspects of what we're doing.

3           The NEA is endorsing it. The proceedings will be  
4 put out, our review will be put out as an NEA document. The  
5 review has started already. Our draft discussion document  
6 will be available in January for review. We've been meeting  
7 with various DOE, NRC groups, academic groups here in the  
8 States. There'll be a workshop, not in early spring, but in  
9 late spring in the south of France. There's a sign-up sheet  
10 in the back of the--no, I'm kidding. But there will be a  
11 workshop that the CEA in France has graciously decided to  
12 host for us, and we will review some of the issues and try to  
13 find if there are common topics internationally by which all  
14 programs could benefit by consulting and comparing notes on  
15 approaches, what's worked, what's not worked for them. As I  
16 say, that's a whole other talk and I'll be glad to talk to  
17 people about exactly what's happening in this area.

18           Coming back to the last two days of talks, this is  
19 a view graph, actually, I got from, I think, Mike Cloninger  
20 awhile back from the DOE, and I like it not because it shows  
21 any sort of circular arguments--although we've heard a number  
22 of those--but it tries to put waste package performance, I  
23 think, into a proper context of its connectiveness to a  
24 number of important functions within our program.

25           I think yesterday we heard an awful lot in the area

1 of waste package testing and modeling, and that's to be  
2 commended, and there's obvious interplay between the  
3 performance assessment model and this effort, and I'll come  
4 back to that in a second in terms of, perhaps, what that  
5 should be, what I perceive it to be in terms of what we have  
6 heard.

7           Today, my sense was that we've heard a lot more in  
8 terms of this coupling of the performance assessment, to  
9 addressing the regulatory issues and compliances; again, a  
10 very central and important role for performance assessment,  
11 but not the only role. And the trouble is, we sometimes  
12 confuse all this different activity that we need for  
13 performance assessment. It's very central to many  
14 activities. It's important to the design process. We heard,  
15 in passing, that some people are now gearing up to look at,  
16 possibly, some of these more robust waste package designs,  
17 and again, I think that's to be commended and we need to see  
18 more of it.

19           Hopefully, the design people are open to the idea  
20 that there could be something useful coming back from  
21 performance analysis. Maybe there's some way to possibly  
22 optimize this a little bit and it won't all be based on good  
23 engineering practices, but actually on something that relates  
24 to performance of the system.

25           I think one of the difficulties in addressing and

1 sort of rolling up the role of performance assessment in  
2 testing is that--this is from Dave Stahl's slide on the first  
3 day, and he had a, you know, another diagram which had a  
4 whole other tier of different test activities below this--is  
5 that when we come up with this kind of flow diagram, what's  
6 passed upwards is a large degree of uncertainty by data  
7 collected, but with certain uncertainty about them, and what  
8 we also heard a lot of in almost everybody's view graph is  
9 the word "need." We need this, you need this, and that is  
10 really the chorus that comes up from below; we need this, we  
11 need this.

12           The real problem, the real difficulty, real need in  
13 the program is not a specific data point, but the need to  
14 sort among these apples, oranges, pumpkins, watermelons, and  
15 try to really, with limited time, limited resources, decide  
16 what is important. That's the role of performance assessment  
17 towards modeling, is providing some sort of guidance and  
18 sensitivity, allowing some sort of equitable comparison of  
19 very different activities.

20           I think we even, on the Nuclear Waste Board, we see  
21 sort of the same approach, is that all of you have certain  
22 important disciplines that you want to see reflected, but--  
23 and that's to the good. What's necessary, though, is how do  
24 we balance all these different importants (sic). Somebody  
25 says, well, advection is important, or heat transfer, or

1 solubility is the most important. We need some integrative  
2 tool--and that's performance assessment--to put these  
3 together.

4           There's a fellow, Dr. Charles McCombie, a few years  
5 ago--he's in charge, or the Technical Manager of the Nagra  
6 program, and for those of you who may not know, Nagra is one  
7 of these programs that when everybody from the U.S. goes over  
8 there and comes back and says, why can't our program be more  
9 like Nagra's? They really seem to be getting things done.

10           Well, a few years ago, Charles McCombie made a  
11 presentation, really a challenging presentation to the  
12 Materials Research Society, which basically I have summarized  
13 here in a sieve, and a sieve is a series of questions. He  
14 says we should ask ourselves, as program managers, about work  
15 that is proposed to us.

16           The first thing he says: Does the study have  
17 scientific merit? If not, well, get lost. I mean, this is  
18 easily done through the standard channel of peer review,  
19 generally. But if the answer is yes, we go to his next  
20 question, which is: Does the study have significant  
21 relevance to waste disposal? Here, if the answer is no, we  
22 should say, seek funding elsewhere. We're not saying it's  
23 bad work, just probably some other group, National Science  
24 Foundation or somebody else; should be funding this work for  
25 you. But how do we do this? How do we rate among the

1 studies that come to us whether it has significant relevance?  
2 This is the role, again, of integrated PA. There's no other  
3 tool for this.

4           If we get together a peer review group of a  
5 chemist, a hydrologist, and a health physicist, and we get a  
6 proposal in one or more areas, you tend to see this skewing  
7 of one person feels great and the other people feel, well, I  
8 don't know where to place this. What you need is people that  
9 are thinking laterally in a number of areas, and have the  
10 tools and integrated PA tool to make a decision on the  
11 significant relevance.

12           Once we have an answer of yes, I think the other  
13 activity we need to focus on is sensitivity analysis, handed  
14 down, if you will, from the modelers or from the modelers to  
15 the testing people to the design people, trying to help them  
16 to prioritize all the work that they have in mind in terms of  
17 barrier performances, processes that are important, site  
18 characteristic data that we need more information on, or  
19 maybe we have enough information on. How do we begin to turn  
20 off some of these spigots of need, need, need more, more  
21 data. How do we reach an end point on this?

22           So that being said, I think my feeling is in the  
23 last few days, we've heard a lot of good information down  
24 here, and sort of looking upwards towards saying, you know,  
25 here are our needs from modeling. We've heard a lot of good

1 information about waste package and the role of regulatory  
2 interpretation. I haven't seen very much emphasis on how PA  
3 is being used to prioritize testing, and say we don't have an  
4 awful lot of money, we don't have an unlimited source of  
5 money. We're going to have to pick and choose, or in the  
6 same way, a sort of a feedback into the design process. So  
7 in that way, I was a bit, I think there's more yet to be  
8 heard from this group on these topics.

9           Now, how am I doing? Where am I, Pat, about ten  
10 minutes? Okay.

11           The last thing I want to say is that I was  
12 disappointed that we didn't hear about, and maybe I'm taking  
13 the Board to task, or I don't know who, but this is similar  
14 to design information that was presented on Monday by Dave  
15 Stahl, about some of these possible alternative designs, and,  
16 I mean, it wasn't in that particular view graph. What struck  
17 me, looking at this version of it, is we're talking about  
18 here distances of this package of almost two meters, or up to  
19 maybe four meters of backfill--or in this case, some sort of  
20 tuff gravel or something like that--between this waste  
21 package and this emplacement drift.

22           Now, the opening talk by Dave Stahl made the  
23 important point that source term modeling is the release from  
24 this engineered barrier system into the host rock. It's not  
25 released from the waste form. That's an important component,

1 but that's not enough. What we need to focus on in addition  
2 is not just release, but transport in the near field,  
3 especially when we're going to start getting into these very,  
4 what are rather long pathways for partially-saturated media,  
5 and I'll show you why I think this is particularly important  
6 in partially-saturated media.

7           This is work done by Jim Conca, reported a couple  
8 years ago. He sort of dropped off the face of the earth  
9 after he left the national lab system, so it's sort of that  
10 if you want to keep current, I guess, you have to stick with  
11 the lab system. But anyway, this is some important work I  
12 think he's done on a variety of material, including gravels,  
13 tuff gravels here, looking at the effect of the diffusion  
14 coefficient as a function of volumetric water, and the  
15 classic models that we're familiar with--at least that I'm  
16 familiar with from these groups with saturated sites using  
17 bentonite, are all up here with a value, basically, of about  
18  $10^{-5}$  cm<sup>2</sup>/second.

19           Now, on the other hand, for gravels, if the reason  
20 is going to gravels, they have very different transport  
21 characteristics. Their type of diffusion coefficients are  
22 going to be orders of magnitude lower than transport in  
23 compacted bentonite; orders of magnitude.

24           Well, why is that such a big deal? Well, we've  
25 seen a lot of the models, and this is a very--since Tom

1 Pickford's not here, I guess I feel somewhat obligated to  
2 flog some of the work that they have been doing for years and  
3 years now. This is a model developed by Chambre'. It's a  
4 simple analytic model, but what I want to use it for is to  
5 illustrate the relative sensitivity that emerges from just  
6 simple models like this. This happens to be for solubility-  
7 limited nuclides, so we see a direct scaling between the  
8 solubility term and the release rate out of the engineered  
9 barrier system.

10           But we also see a direct scaling from the diffusion  
11 coefficient; i.e., if we can demonstrate that these gravel  
12 barriers have a low transport rate, three orders of magnitude  
13 lower than perhaps what these other groups are using in  
14 saturated repository systems, maybe three orders of magnitude  
15 is rather significant. Maybe we ought to study a little more  
16 about the transport, because the other factor that comes out  
17 of transport is that--well, there are two other factors.

18           One is that the retardation term, which is sort of  
19 embedded here in the  $K_b$  term, is also a function of  
20 volumetric water content. As that volumetric water content  
21 goes down, reciprocally, the retardation in the gravel goes  
22 up, goes up considerably. So in two ways, we're getting a  
23 lot more performance if we gain a little more understanding  
24 about transport in the near field. And again, I think that  
25 was a missing technical element from this meeting.

1           We heard a lot about the chemistry. We heard a lot  
2 about the materials. Those are very important topics, but  
3 what was missing, I think, or what we need to hear more of  
4 and the Board needs to hear more of and to consider, is what  
5 is the role of transport in these type of systems.

6           Just to show you the effect, this is some work that  
7 was done, actually, for bentonite for Nagra, some work we did  
8 for Nagra awhile back. But here's the bentonite;  $b$  is  
9 bentonite thickness. This is basically a term--this  $D$  term  
10 that was in the other equation--bentonite thickness, decay  
11 constant, retardation, and diffusion coefficient. And if you  
12 can get this term, so a thicker backfill or a higher  
13 retardation coefficient, or a lower diffusion coefficient,  
14 all of which is likely to emerge from a better understanding  
15 of transport in gravels, we're going to be able to limit the  
16 release rate out of this system, or maybe decrease release  
17 rates by orders of magnitude.

18           The other thing that at least I like about  
19 transport is that, for example, if we're interested in  
20 neptunium or plutonium and Americium, we've got to go out and  
21 we've got to get separate information on each and every one  
22 of those radio elements. I'm not knocking that. I think we  
23 do need to do that, but notice that the release rate of all  
24 those radionuclides, all, every one of them, are going to be  
25 a function of the diffusion coefficient in this system.

1           So with one measurement, we're gaining a lot of  
2 understanding, and perhaps a more favorable performance for,  
3 essentially, the periodic table.

4       DR. DOMENICO: Mick, can you close?

5       DR. APTED: This is my last one.

6       DR. DOMENICO: All right. I don't want to cut into our  
7 discussion period too deeply.

8       DR. APTED: Yeah, I know; the last one, also work by  
9 Conca, and this relates to some of the other issues that  
10 emerged from this when we started considering transport, and  
11 that is some of the questions about whether we really need to  
12 know surface area, to what degree, whether colloids are going  
13 to transport, and that is in partially saturated systems as  
14 we expect at Yucca Mountain, through gravel barriers, there  
15 is essentially no--the available evidence indicates there is  
16 no colloid transport, usually because--or conceptually  
17 because what we have is very thin, basically monolayers of  
18 water that are dominating the actual diffusive transport, or  
19 very inefficient sort of diffusional pathways through these  
20 grains.

21           Because these diffusion coefficients are so low,  
22 again, it's this mass transfer resistance, not changes in  
23 surface area, that are going to dominate the release even of  
24 the alteration rate-limited elements, and so a lot of the  
25 attention that we paid yesterday to things like surface area

1 models and colloids, and so on, may--I'm not saying are, but  
2 may all be knocked out if we start considering the transport  
3 factors.

4           Thank you.

5           DR. DOMENICO: I'm going to hold discussion. If Mick  
6 said something that doesn't set too well, I'm sure you can  
7 get him during the discussion period.

8           And our last formal presentation here, up to the  
9 discussion period, will be from Nava Garisto from Beak  
10 Consultants, Limited.

11          DR. GARISTO: I'm going to give a Canadian perspective  
12 on source term models, and although the Canadian program is  
13 not perfect, I think that some of its successes are due to  
14 the fact that we have been consistent with the  
15 recommendations that Mick has been doing today in terms of  
16 both the leadership role of performance assessment, and the  
17 integral part of transport modeling in the source term  
18 development.

19          In this context, source terms, again, are the flux  
20 of radionuclides at the exit from the engineered barriers,  
21 and it's the flux at the interface between the engineered  
22 barriers and the surrounding geological medium, which in our  
23 case is plutonic rock. Our engineered barriers include  
24 metallic containers, clay-based buffer, and backfill layers,  
25 and in this sense, it's actually quite a similar system.

1           So in this presentation, I will very briefly go  
2 over the source term for the Canadian concept, which includes  
3 container failure, release from the fuel, and includes mass  
4 transport as an integral part, but I won't go into details.  
5 I'll just try to point out those points that may be of  
6 interest to the U.S. program. In this sense, I'll go over  
7 just assumptions, improvements, and why we carry out these  
8 improvements, what are the practical limitations.

9           I'll try to focus on issues that are not very  
10 specific to a particular site or a particular design, so that  
11 the conclusions will be of interest to you, and as an  
12 example, I'll cover some issues that have to do with the  
13 probabilistic nature of some source terms that are related to  
14 risk assessments. And finally, I'll just make a few  
15 recommendations regarding ways to enhance the credibility and  
16 acceptability of source term models.

17           All right. So the first barriers that we are  
18 looking at is the container. In Canada, we are looking at  
19 titanium and copper, and I understand that titanium is not of  
20 much interest in the American program, but I want to say just  
21 a few words about it, because first of all, those of you who  
22 are looking at zircaloy may, instead of starting from scratch  
23 in terms of developing a zircaloy filler model, you can steal  
24 a lot of the methodology from this model, because the two  
25 metals behave very similarly. So that's one reason why I

1 mention it.

2           The other reason is in the development of the  
3 titanium, a container failure function has been guided by PA.  
4 We had assumptions in the model; for example, we have the  
5 natural defects, we have corrosion along the containers. We  
6 assumed that there is sufficient oxygen to allow for a  
7 unlimited propagation. We have hydrogen-induced cracking  
8 below a certain temperature. We don't take credit for the  
9 mass transport properties of a container, and we don't take,  
10 explicitly, microbial activities into effect.

11           We know that we can improve the models, but we  
12 don't go into these improvements if the performance  
13 assessment, for example, show us that the containers, on one  
14 hand--that the models, on one hand, are conservative enough;  
15 that is, the improvement will just lower the dose, especially  
16 in those cases where we don't have to lower the dose, where  
17 we know that we meet the criteria.

18           On the other hand, if we know from performance  
19 assessment and sensitivity analyses that a certain feature  
20 maybe hasn't been done in detail enough, or maybe it's not  
21 conservative enough, then we know that we should spend more  
22 effort on this particular point.

23           Regarding the copper container, what we have here  
24 is a model that combines mass transport with corrosion. The  
25 corrosion rate is controlled by mass transport of corrosion

1 products away, and we will improve it by also including mass  
2 transport of oxidants towards the container.

3           And again, the points that I would like to make for  
4 the American program is that the only way to get realistic  
5 corrosion models is by combined effort of corrosion  
6 scientists with mass transport specialists and  
7 hydrogeologists. In our case, the corrosion behavior of  
8 copper depends on the hydrogeology of the site, and I haven't  
9 seen that much of this joint team effort in the American  
10 program.

11           Realistic models require this kind of dialogue, and  
12 if you have only corrosion people defending the model, or  
13 only the performance assessment people defending the model,  
14 the credibility's going down, because it's only through the  
15 joint effort that people are ready to support this kind of  
16 model.

17           All right. So then the next barrier that we are  
18 looking at is spent fuel, and we have again short-term and  
19 long-term release models, similar to your program. The  
20 short-term release is instant release for gap and grain  
21 boundaries. In our case, the zircaloy is not a barrier, and  
22 if you compare the two programs, the rationale for it, I  
23 think, is that in your groundwater, the chloride  
24 concentration is very low, and in our groundwater, the  
25 chloride concentration is high, and that's why, you know, the

1 environment interaction there is very severe, so they say  
2 that if the zircaloy can withstand the environment  
3 interaction, why should it fail once, you know, once it's  
4 outside the radiation field? The thing is, the zircaloy is  
5 very sensitive to high concentrations of chlorides, and in  
6 our environment, we can't--we assume that the zircaloy would  
7 fail within a year, and that's not, you know, if it fails  
8 within a year, it's not worthwhile to take credit for it.  
9 But we may revisit it, especially to look at maybe better  
10 models for the release of radionuclides that are trapped in  
11 the zircaloy.

12           In terms of the long-term release, we have  
13 congruent release of radionuclides, solubility-limited, from  
14 dissolving the fuel matrix, because we assume that the redox  
15 conditions are below  $U_3O_7$ . There is some effort now in the  
16 program by Frank Garisto and by Dave Shoesmith to include the  
17 radiolysis effects, which again are probably of less  
18 importance in the American program, but the methodology used  
19 can be--is applicable, also, to oxidizing conditions. So in  
20 this sense, again, there is some similarity, and I think the  
21 two programs can probably learn from each other.

22           The thing that we have included and, I guess, was  
23 referred to often was organics, and we did an analysis of the  
24 effect of organics on the source term. And in our case, the  
25 effect wasn't large.

1           The other effect that we have is precipitation,  
2 both of secondary phases, and of the uranium itself, so we  
3 have included diffusion and precipitation coupling in the  
4 model. I don't think that this is as important in the  
5 American program as in the Canadian program because you have  
6 more oxidizing conditions, but this is something that is  
7 missing from the glass model. The glass model that you have  
8 is affinity-limited, and with a precipitation downstream, for  
9 example, in the presence of iron particles, you have to  
10 include this kind of coupling.

11           You know we have applied it for fuel, but the  
12 methodology in the model is the same, and I think that for  
13 the people who are doing the glass dissolution modeling, it  
14 may be interesting for them to see how we coupled diffusion  
15 and precipitation processes.

16           The other thing that we have done and can be of  
17 interest in the American program is we have looked at the  
18 effects a calcite precipitation, on how it slows down the  
19 movement of CO<sub>2</sub> and carbonate. This was very preliminary  
20 work. We developed a couple of reactive transport models for  
21 this. We've showed how the cell can be, maybe, projected  
22 into an equivalent Kd kind of a model in case--for those  
23 people who can't handle the coupled reactive transport code,  
24 and again, this can be a starting point that can be of  
25 interest to the U.S. program.

1           In all of this derivation, the fuel behavior  
2 defines a boundary condition for mass transport equations,  
3 for transport of dissolution products away from the fuel, and  
4 the flux that is calculated from these equations is the  
5 source term. And again, I think that the strengths of the  
6 Canadian program in this was the fact that the source term  
7 was developed not by mathematicians, and not by geochemists.  
8 It was developed in a joint effort of electrochemists,  
9 material scientists, and theoreticians with a mass transport  
10 and hydrogeological background.

11           Mass transport, in our case, is an integral part of  
12 the source term. It's coupled to the source term and it  
13 affects it. In the EIS, which is the concept assessment, we  
14 have an analytical model with sectors, with mass transport  
15 coefficient boundary conditions and other simplifying  
16 assumptions, but we are working on ways to improve the  
17 models. For example, we do have a mass transport model now,  
18 and it has recently been incorporated into the assessment.

19           And again, whether we carry out these improvements  
20 or not depends on performance assessment, so the cycle that  
21 Mick has alluded to is actually being practiced in the  
22 Canadian program, and I think it's working relatively well.

23           So the bottom line on these sub-components are that  
24 it's important for experimentalists and theoreticians to work  
25 together in a project team, and I think that it's even

1 important that they will be under the same roof. We've seen  
2 some nice collaboration, for example, in the glass program  
3 between people in Argonne and somewhere in California. I  
4 feel that most progress that I have done, for example, in  
5 source term development has been over coffee breaks, over  
6 daily contact with the experimentalists, because it's very  
7 difficult for a modeler like myself to gain the trust of an  
8 experimentalist, an "oh, you are just playing with numbers,"  
9 and you need this daily contact to gain a respect for each  
10 other and to work together. So you need a model that is  
11 developed and defended both by the experimentalists and by  
12 the mathematicians.

13           I have just a few points to make on the statistical  
14 nature of the model. We have seen that people are using  
15 different distribution functions. Sometimes they use  
16 probability, sometimes they use uncertainty. The first thing  
17 that I would like to point out is that it's quite dangerous  
18 to mix all these things and to lump them into one delta, or  
19 one sigma. Variability is not the same as uncertainty, and  
20 it's not the same as probability, and we don't have time to  
21 get into details here, but even in our program, we mix all of  
22 them and it's just not valid.

23           Also, people tend to replace time dependence by a  
24 wide distribution function, and again, sometimes it's valid,  
25 sometimes it's not. It has to be checked. All along the

1 model, there should be a consistent treatment of uncertainty  
2 in the first components. You can't just have uncertainty in  
3 one part, and then forget about it in the other one.

4           I have done, you know, I have seen here, too, you  
5 know, sometimes when you take a very simple model, it's very  
6 difficult to assign an uncertainty to it, you know. It's  
7 much easier to assign uncertainty to data, you know, the data  
8 is  $\times$  such and such, but if you use a simplified model  
9 instead of a more realistic one, how will you know what kind  
10 of delta to put on it? And all of these things have to be  
11 taken into account because the final result with the  $\times$  has  
12 to reflect the uncertainty in the sub-components.

13           Specifically, the recommendation that I would make,  
14 especially for the short-term release, is again to look at  
15 some of the work that we have done in Canada regarding the  
16 probabilistic nature of the instant release inventories for  
17 container. We've done it for gap and grain boundary release.  
18 It was a very preliminary work. It's not something that I  
19 am too proud of in terms of inconsistencies and things like  
20 that, but it's a starting point and I haven't seen a similar  
21 kind of approach in the U.S. program.

22           All right. That's the last slide. There are the  
23 usual ways to enhance the credibility of source term models,  
24 like we all talk about sub-component validation, and there  
25 were some references this morning to natural analogs. Some

1 of these are good. I would like to just mention three which  
2 I personally like.

3           One is benchmarking. I was quite encouraged by a  
4 few comparisons that were mentioned today. They weren't  
5 mentioned in detail, but I think that there is some effort  
6 towards this, and that's encouraging. And to all this, I've  
7 done some comparisons with Mick, and I think that that was of  
8 benefit to both programs. I learned a lot from these  
9 comparisons, and I would very much recommend it to continue.  
10 It's not validation, but it's a step in terms of  
11 credibility.

12           The other thing is the role of performance  
13 assessment, and I guess I would just reiterate what Mick was  
14 saying earlier. In substance, we need a wide scope program,  
15 but it has to be focused, and otherwise, you know, you ride  
16 off in all directions, and the focus has to be provided both  
17 by data sensitivity analysis and by model sensitivity  
18 analysis, and that's the role of a performance assessment.

19           The last point comes mostly from the fact that I've  
20 recently moved from ACL to the private sector, and I have  
21 started to have experience in defending what you are doing in  
22 court, and when you are talking to the public or when you are  
23 talking to specialists from outside your field, and there are  
24 beautiful animation programs available now, and sometimes  
25 what we present to other scientists is too complicated, it's

1 lists of numbers. We are talking here about a complicated 3-  
2 D design with hydrogeology and with source terms. There are  
3 gaps in the communication between us even in this room. Once  
4 we want to go out and sell these kind of concepts to people  
5 outside the program, I think that we will have to improve our  
6 presentation methods.

7 Thank you.

8 DR. DOMENICO: Thank you very much, Nava.

9 Well, we've come to the point in the program that  
10 everybody's been anxiously waiting for. We have  
11 approximately twenty minutes for an open discussion, and by  
12 open, I think we really mean open. We would like very much  
13 to hear from the silent audience out there.

14 Comments, questions to any of the participants?

15 DR. YOUNKER: Hi, I'm Jean Younker with the M&O, and  
16 Carl Gertz did ask me to respond to a comment that Mick Apted  
17 made when he was talking earlier, and that was to Mick, you  
18 might not be familiar with this, but we have given a number  
19 of presentations to the Board of tasks that we have done in  
20 the past, and we have one that we're just kind of completing,  
21 where we've taken every bit of performance assessment  
22 intelligence that we can possibly apply in an attempt to use  
23 it to focus the site program to ask the question: What kind  
24 of data is going to be most useful in assessing whether we  
25 have a suitable site, and also in assessing whether we can

1 meet the regulatory standards that are out there?

2           So I think, you know, we've tried our best. You  
3 know, I agree with you that making that link is a tough one  
4 to do, but I think we have really had a pretty concerted  
5 effort to do that, and the Board has been informed on that.

6           DR. APTED: Yeah, no problem with that, just all I can  
7 comment on is what we saw in the last two days, and we  
8 certainly didn't see anything like you just suggested, so...

9           MR. BOAK: I'm Jerry Boak. I'm the Technical Analysis  
10 Branch Chief for the Yucca Mountain Project, and I guess that  
11 makes me the current bad parent in Mick's scenario about the  
12 orphan child of engineered barrier performance assessment.  
13 We haven't really been abusing them, although they may be a  
14 little shoeless these days.

15           I wanted to mention a couple of things; that Bill  
16 Halsey reminded me of a presentation that was done at one of  
17 our internal meetings, and Mick turns up in some strange  
18 places, but he didn't happen to turn up in that one, in which  
19 Joe Wang presented an analysis of borehole versus drift  
20 emplacement, and the effect of the backfill on that, and we  
21 do see a substantial improvement. There are some sensitivity  
22 studies that we haven't gotten ready. To some extent, our  
23 agenda here was constrained by some specific requests, and  
24 our attempt to try and get the right information, but we  
25 haven't gotten everything that could go on it.

1           With respect to Nava's comment about housing  
2 experimentalists and theoreticians under one roof, I think  
3 we've gone one better by getting them all out from under the  
4 roof and dragging them out into the field, the theoreticians  
5 kind of kicking and screaming every step of the way. But  
6 some of them came back with some interesting insights from  
7 actually having a chance to talk to Alan Flint and see what  
8 rocks look like outside of the computer.

9           And I think she also raised one of the points that  
10 we've been addressing a great deal, about the question of  
11 abstraction of models: How do we go from something that we  
12 can run thousands of iterations? How can we get answers to  
13 the vast array of scenarios and potential ranges of  
14 variables? We don't think at present we're able to do that  
15 using full, completely implemented and completely coupled  
16 process models. We are driven to the kind of simplified,  
17 higher-level models that we've shown in our diagrams of the  
18 pyramid that we showed.

19           Thank you.

20         DR. DOMENICO: Was that a comment, question? Mick, do  
21 you want to respond to it; or Nava?

22         DR. APTED: Well, I'll just add I don't mean to make the  
23 assertion on that, that I know there are activities that  
24 connect the design to the PA and the testing, and so on. It  
25 was just, again, perhaps at this meeting we haven't heard as

1 many things as I sort of knew about and was sort of actually  
2 fishing for some more amplification from DOE.

3 DR. DOMENICO: Well, I'll make a comment.

4 Yeah, I see a gap between the detail presented  
5 yesterday, and the source terms presented today. Obviously,  
6 all of the information that we heard yesterday has not yet  
7 been captured in the essence of these models, and perhaps  
8 some of it is not important and perhaps it never will be  
9 captured in the essence of these source terms.

10 So when we talk about transport modeling, the  
11 source term is the most important thing that we have to deal  
12 with, the concentration that rock sees is going to determine  
13 basically what's going to end up at where you make your dose  
14 calculations, and if we're several orders of magnitude off  
15 there for some reason or another, we're several orders of  
16 magnitude off in the far-field calculations.

17 That said, I'm impressed with the progress that has  
18 been done because at least I now feel I know something about  
19 what was in the models that we heard a few years ago in a  
20 performance assessment meeting. At that time, all we got was  
21 far-field information, output, output, output, CCDF's, or  
22 what have you, and never any details of what went on inside  
23 the models; no physics, and just no details, and I, for one,  
24 feel that this morning has been quite successful, at least in  
25 trying to ferret out what processes, chemical and physical,

1 are being incorporated in the source term model, so I feel  
2 pretty good about it.

3           Does anybody on the staff have a question or  
4 comment? Board? Dennis?

5       DR. PRICE: Dennis Price; Board.

6           Just a quick comment. We heard a conservative  
7 model presented in which it didn't satisfy the criteria in  
8 some ways, and so the answer, since it didn't satisfy the  
9 criteria, was it's too conservative, and so we need to go  
10 back and change the model.

11           We also heard a "realistic" model presented, and it  
12 was based on expert judgment. It satisfied the criteria.  
13 You might ask, if it didn't satisfy the criteria, what is the  
14 response? Do you get other experts, or do you go back to the  
15 experts and say, it didn't satisfy the criteria, and it  
16 sounds like in this sort of fuzzy business of model building,  
17 it's easy to get circular, and I think the issue that was  
18 mentioned from the floor about validation, not verification,  
19 but validation, is still at the crux of it, but with such a  
20 long term, it's an extremely difficult problem. That's just  
21 a comment.

22       DR. DOMENICO: Anything further from anybody? You mean  
23 we're going to--yes?

24       DR. O'CONNELL: Bill O'Connell from Livermore.

25           I feel that we could do a lot more in expansion of

1 the simplified models. The progress that we have made over  
2 the past year or two has been a modest amount of progress,  
3 limited by funding. I realize most of the other parts of the  
4 project are also limited by funding, but we could make a lot  
5 more progress in incorporating some of the information that  
6 is becoming available from the detailed studies.

7           And second, we could do, you know, much more  
8 thorough and consistent treatment of uncertainty. The models  
9 really cannot be used to cut off some experimental studies,  
10 because the models are not robust enough and the input data  
11 are not robust enough. But perhaps by using uncertainties  
12 consistently, we could provide the robustness and show  
13 whether things matter or don't matter.

14           Now, the Golder Associates has a total system model  
15 which is including uncertainty in this way, and the EPRI  
16 model, by running through the CCDF's, they are effectively  
17 covering uncertainty, but there is a lot more that can be  
18 done, you know, starting from the simplified models and  
19 expanding them at the same time that detailed models and  
20 detailed experimental studies are underway and producing new  
21 information.

22           DR. DOMENICO: That's a point well taken. The thing  
23 that I'm still curious about is that if I had your four codes  
24 and I fed exactly the same information into all of them,  
25 assumed everything the same, the source concentrations that I

1 predict, I presume, are going to vary all over the map, and I  
2 would be curious to find out the results of such an  
3 experiment like that, and I think that becomes important when  
4 NRC is developing their own to, in the words of Dick, keep  
5 them honest. And so there is variation there. I think that  
6 the processes covered have been covered in different detail  
7 by different groups, but your point is well taken.

8           With that, I'm going to turn the final discussion  
9 over to Warner North from the Waste Board.

10       DR. NORTH: Okay. I think I'll go up to the podium so I  
11 don't have to have my back to everybody.

12           I'd like to start off by thanking everybody. I  
13 think we've had a series of excellent presentations, a lot of  
14 good comments, and I'd especially like to thank our two  
15 consultants, Nava Garisto and Mick Apted, who have, I think,  
16 done an excellent job of making the points that I had  
17 intended to make, among other things, which simplifies my job  
18 considerably.

19           Nonetheless, I think it's useful to reiterate some  
20 of those points, just to stress their importance and set  
21 forth a clear agenda for some future meetings.

22           We have had, I think, in the last two days, a lot  
23 of very impressive and interesting material regarding  
24 processes and mechanisms related to the source term. I will  
25 certainly speak for myself to say that I've learned a great

1 deal and have found it all extremely useful.

2           On the other hand, I've been quite disappointed.  
3 We haven't seen the kind of iteration and priority setting  
4 based on interaction between the scientific researchers and  
5 the performance assessment people that I would have liked to  
6 have seen, and I think Nava's right-hand column, what is the  
7 impact of the information, is just exactly what we were  
8 missing. That was relatively simple, and relatively  
9 quantitative, but in most cases, you had an indication of  
10 direction. Which way might this issue take us; higher  
11 numbers, or lower numbers? And what kind of thing might we  
12 need to do in order to resolve the issue and get better  
13 numbers?

14           Then we can turn that into questions of priority  
15 for a particular experiment or a set of tests, or further  
16 refinement in the analytical models, or perhaps more  
17 elaborate uncertainty analysis, and I hope we're going to see  
18 a lot of that. I'm encouraged by Jean and Jerry getting up  
19 and saying, well, it's coming. We've been doing it over on  
20 the site. We've been carrying out sensitivity analysis that  
21 is not yet presented, but then I go back to the point Mick  
22 was making, of how much of this presentation that we heard  
23 was directed at what I'll call the big issues of the  
24 regulatory criteria as opposed to the smaller scale issue of  
25 repository and engineered barrier system design.

1           It would have helped a lot, I think, if many of the  
2 presentations had been developed around several alternative  
3 designs for engineered barriers, maybe even some of the  
4 questions having to do with the repository design that are  
5 being considered in other meetings. That way, I think we do  
6 a lot better job of getting some insights as to what is  
7 important.

8           I'm concerned that the style of much of the  
9 presentation is, here is an overview of the processes and  
10 mechanisms and what we know about the science, and then we  
11 come down to some calculations of numbers--hopefully, we'll  
12 see a little bit more sensitivity analysis, rather than just  
13 one set of results--but what we're not doing at this point is  
14 going back and getting an iteration. Now that we have some  
15 numbers calculated, what are the driving issues? Which of  
16 these mechanisms and processes appear to be the most  
17 important, and why? What have we learned from the modeling  
18 exercises that we've just been through?

19           Now, I think there's a lot of experience in the  
20 nuclear industry in carrying out very complicated analyses on  
21 safety issues concerned with reactors, and a lot of these  
22 issues of how do we manage the process, I think, have been  
23 learned in that context.

24           We started out with exercises like WASH-1400, the  
25 very elaborate attempt to calculate a bottom line; how safe

1 were nuclear reactors? Then I think we got some very  
2 insightful criticism from people like Hal Lewis and Bob  
3 Budnitz in a review they did of that whole exercise, and the  
4 way I remember their major theme is that you have to  
5 recognize the assumptions and the uncertainties that go into  
6 those calculations, such that if you try to get an absolute  
7 bottom line result out--"How safe is this? What is the  
8 performance of the reactor or the repository?"--it's very  
9 hard to defend the strength of that number. It's a soft  
10 number rather than a hard number.

11           On the other hand, if you use the analysis as a way  
12 of looking, what difference does some change make? What if  
13 we add one more backup system, or we make a pipe or a brace a  
14 little thicker, what difference does that make on the risk?  
15 Is it a big number or is it a little number? That can help a  
16 lot.

17           I think Mick was just explaining to us one example  
18 on the transport, that if you start doing some detailed  
19 analysis of the effect of crushed tuff or gravel, we may find  
20 that you can pick up orders of magnitude in the performance  
21 of the repository for a very, very low cost, and I submit  
22 that's where we ought to be focusing.

23           We ought to be using the analysis as the engine of  
24 evolution, and we ought to be iterating around this loop, and  
25 we ought to be using it to inform the top management what are

1 the most critical issues, and provide a basis for planning,  
2 where, as we go through this era of very tight budgets, we  
3 can direct the funding and the scientific resources in the  
4 most productive way, with full attention to the time scales  
5 so that we can start the long lead time information gathering  
6 and analytical activities in an appropriate time to have the  
7 results where they can make a difference in design decisions,  
8 as well as the questions of overall site suitability.

9           Now, I'd like to conclude by making a few remarks  
10 about the teamwork issue, again, picking up from some of the  
11 remarks that were made by Nava and Mick. I'm very impressed  
12 with how much international commonality there is on these  
13 issues. The Board has had the opportunity to travel to a  
14 number of different countries and see what their programs are  
15 doing, and there certainly is a lot that can be learned about  
16 source term by taking advantage of the international  
17 community, and I think our two consultants have done a  
18 marvelous job of providing us with a brief summary of that.

19           The issue of having the performance assessment  
20 people and the scientific investigators from a multitude of  
21 disciplines all work together seems to me very critical.  
22 It's hard to do that under one roof, given the institutional  
23 structure of the U.S. program. It's certainly a great idea  
24 to get people to go together out in the field and trade  
25 information out there, but it seems to me there is a

1 tremendous value to coffee break communication, to use Nava's  
2 phrase, of having people see each other frequently and  
3 communicate in an informal way, as opposed to just formal  
4 meetings, so that they can understand each other's point of  
5 view and find ways of working together that may be very hard  
6 for the management to be able to accomplish, other than  
7 essentially enabling the informal communication to take  
8 place, and letting people find effective ways of working  
9 together because there is a clear incentive to do that.

10           So as I think about where we're going on source  
11 term and the performance assessment area more broadly, it  
12 seems to me these issues of teamwork are really quite  
13 critical. We have a lot of pressure in terms of the time and  
14 the schedule, and we have some pressure in terms of how  
15 difficult it is to provide continuity of effort. It's really  
16 hard to keep a team working effectively when we get some new  
17 players coming in and we get some other players going out.  
18 We had an example that Mick presented of somebody who's  
19 apparently done some very valuable research, who's no longer  
20 available in the national lab system.

21           So it seems to me that in thinking through where  
22 this ought to go, the questions of how to build, maintain,  
23 and enhance the team are really very important, but what I'd  
24 like to conclude on, as overall, I think we've had an  
25 extremely useful and valuable meeting, and, really, the issue

1 is how can we continue from here and make a great deal of  
2 progress, putting these ideas into effect to help the  
3 Department of Energy have a more effective program.

4 DR. DOMENICO: Thank you, Warner.

5 My agenda says we have just listened to the  
6 concluding remarks on the source session, so I suspect we are  
7 near conclusion.

8 I want to thank all the speakers we had this  
9 morning for their deliberations, and DOE for its  
10 organization, and the audience for its participation.

11 We're done until two-fifteen.

12 (Whereupon, a lunch recess was taken.)

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AFTERNOON SESSION

8 DR. ALLEN: May we reconvene, please?

9 I'm Clarence Allen, Chairman of the Board's Panel  
10 on Structural Geology and Geoengineering, and it's my  
11 privilege to introduce the next speaker.

12 Last month, a number of us were on a field trip to  
13 Yucca Mountain and we were exposed for the first time to some  
14 of the detailed field mapping that's been done over the past  
15 few months by the U.S. Geological Survey on the Ghost Dance  
16 Fault, and some of us thought this was of significance enough  
17 to the program that we ought to be briefed on some of the  
18 recent findings there today.

19 So the person in charge of that particular project  
20 is Rick Spengler. I'll introduce Rick Spengler now.

21 MR. SPENGLER: Thank you, Clarence.

22 Let me just briefly mention that this particular  
23 study, detailed mapping of the Ghost Dance Fault, was  
24 initiated the beginning in FY92, and we are in the process  
25 now of field-checking our maps, quality checks of the maps,

1 writing our open file report on our findings to date, and we  
2 intend to submit this for technical review within the next  
3 few weeks.

4           With that in mind, it's a bit unique in that under  
5 a normal process, review process, we wouldn't want to present  
6 the data until we have an opportunity to do our analysis of  
7 the data, do our complete field-checking and complete  
8 technical review, but obviously, because of the importance of  
9 new information regarding the potential repository area, we  
10 certainly welcome the opportunity to present some of these  
11 early findings.

12           Just as a brief overview, the rock characteristics  
13 section, the rules and responsibilities are the collection ,  
14 analysis, and interpretation of geologic and geophysical, as  
15 well as geochemical data to be incorporated in a three-  
16 dimensional geologic model of the site area, and this  
17 particular three-dimensional model in turn feeds information  
18 to a number of other models, a number of other assessments,  
19 as well as other concerns.

20           To name some of those, we've got this information  
21 that we collect, geologic information provides data to the  
22 site structural, tectonic models, seismicity models; the  
23 site-scale unsaturated zone model; transport pathways or the  
24 saturated zone concerns the fast transport pathways and the  
25 steep gradient to the north of Yucca Mountain; geochemical

1 models; resource assessment; and then, finally, supplies  
2 information to design and performance assessment of the  
3 potential repository.

4           The way that we have our studies within the rock  
5 characteristics section organized, the three major components  
6 all feeding into the 3-D geologic model; those being geologic  
7 mapping, stratigraphic studies. Our mapping until FY92 was  
8 basically the mapping by Scott and others at a scale of  
9 1:12,000, or one inch equaled 1,000 feet. We had a number of  
10 stratigraphic studies ongoing to measure sections in and  
11 around the vicinity of Yucca Mountain. Those, in turn, other  
12 components including any of the subsurface drilling,  
13 supplying subsurface information, as well as borehole  
14 geophysics and surface-based geophysics, both feeding into  
15 the geologic model. We also recognized the need for the  
16 underground geologic mapping to feed into the overall model  
17 to complete the correlation of surface and subsurface.

18           As kind of a brief summary here, there was interest  
19 in the Ghost Dance Fault on the site tour, the NWTRB site  
20 tour held June 28th, 1989, and at that time, at the stop--one  
21 of the stops being at the Ghost Dance Fault--there was a  
22 summary given of some of these components. The summary  
23 includes that the Ghost Dance Fault is a high-angle, west-  
24 side-down normal fault. It offsets the 12.7 million-year-old  
25 Tiva Canyon member or the Paintbrush Tuff. Down to the

1 south, the southern end of the potential repository, it  
2 offsets strata about 100 or so feet. As it extends  
3 northward, it dies out into a fractured zone. This is well-  
4 documented in the Scott and Bonk map, 1984.

5           The work by Swadley and others, 1984, indicates  
6 that no quaternary offsets were found along that fault. The  
7 fault is expressed by the offset of strata, the presence of  
8 breccia zones, slickensides, and the positive relief on the  
9 upthrown side of the block. The fault dips 79° to 90° at  
10 the surface, and I also inferred at that time that the  
11 character at depth is pretty well unknown. It maybe a single  
12 fracture or it may be a set of fractures, may be a listric  
13 fault, and that other faults or fracture zones may be  
14 present. We didn't anticipate any major structures; however,  
15 at that time, I also pointed out that there were minor faults  
16 and fractures are probably numerous throughout the area.

17           In the Ghost Dance Fault study, our objectives for  
18 this particular, for FY92, was to combine some of our  
19 fracture mapping with some detailed geologic mapping to  
20 better characterize this particular fault. The objective  
21 here in our discussions and integration meetings with the  
22 unsaturated zone modelers, one of the components that was  
23 mentioned was the need for structural data within their site  
24 scale model area, and so the primary objective was to provide  
25 data for the unsaturated zone model.

1           We wanted to initiate a study within the confines  
2 of one fiscal year to test out our technique. We wanted to  
3 also establish some type of grid system to be used here so  
4 that if the study proves to be worthwhile, that we can later  
5 expand on our network.

6           This is a map of Yucca Mountain. This is taken  
7 from Scott and Bonk, 1984, showing the potential repository  
8 area and some of the structures that are from Scott and Bonk.  
9 The major throughgoing feature within the potential  
10 repository area, obviously, is the Ghost Dance Fault, shown  
11 here, and along the Ghost Dance Fault there, Scott had mapped  
12 a number of areas showing breccia. I might also point out  
13 within the potential repository area, Scott had also mapped  
14 several other structures, one being the breccia zone along  
15 this particular north-trending feature, a number of breccias  
16 found throughout. I also point out that he did see these  
17 linears as far as a northwesterly fracture trend in other  
18 areas of Yucca Mountain, some discontinuous faults to the  
19 south here.

20           I'd also point out he did map at least two other  
21 faults to the east, until he hit what we are now referring to  
22 as the broken zone on this side of Yucca Mountain. This  
23 particular scale here, this grid system, this grid here on  
24 the side is 4,000 feet. This is our study area for FY92. We  
25 decided to cover an area--straddle the Ghost Dance Fault to

1 the south here--it's a width of about 800 feet--as we extend  
2 northward, our width of our study area decreased to 600 feet.

3           We established a grid system based on the Nevada  
4 state coordinates. This attempt to do this is so that we can  
5 go back and expand on our grid system. We have mapped 61  
6 areas along the Ghost Dance Fault. Each area is labeled.  
7 Each area is 200 x 200 foot square, and it includes  
8 everything from the southern part up to about the middle part  
9 of the Ghost Dance Fault.

10           Our blocks here are labeled based on the coordinate  
11 system. We just kind of drop the first and the last three  
12 digits of the northing and the easting to come up with a  
13 designation for the block, and then we go ahead and subdivide  
14 the block into 200 x 200 foot squares.

15           I would also point out that our study area includes  
16 the south face of Antler Ridge. It includes both faces of  
17 Whale Back Ridge, and to the south here, includes the  
18 northern face of what we call Broken Limb Ridge.

19           Just for an explanation here--I'll go through this  
20 quickly--we had two types of mapping here in that we wanted  
21 to map where we had alluvium, colluvium, and then also we  
22 tried to map out where our area partially covered with  
23 colluvium. Now, our definition here is that we can still see  
24 large-scale features showing through the cover, but it still  
25 is partially covered. Our lithologic section that we've

1 measured out at Yucca Mountain includes everything from the  
2 Cap Rock down to the Hackly Unit. The Columnar Unit occurs  
3 directly beneath the washes.

4           This is an example of one of our areas, our 200 x  
5 200 foot areas, 6262B; 200 x 200 on the side, and then when  
6 we're out in the field, we go ahead and make up a temporary  
7 grid and divide up this area into 40 foot increments. In  
8 this particular case, this is along one of the areas along  
9 Antler Ridge, indicating where we've mapped some of the  
10 breccia zones. This is the main trace of the Ghost Dance  
11 Fault here, and we found breccia zones in other areas. We've  
12 mapped fractures, we labeled the fractures, and what also is  
13 present on this is the breakdown or contacts of the units.  
14 In this case, this is the upper lithophysae unit here, this  
15 being CKS, the Clinkstone Unit.

16           So our fracture mapping mapped at a scale of one  
17 inch equalled 20 feet. We mapped fractures or sets of  
18 fractures that measured six feet in length or longer. Our  
19 fracture attributes included the location, the length of the  
20 fracture, the elevation, lithology, attitude, spacing,  
21 roughness coefficient, and fracture mineralogy.

22           Likewise, in our fault mapping, mapping at the  
23 1:240. We were mapping the location, nature, and continuity  
24 of some of the breccia zones, offsets that we see in the Tiva  
25 Canyon Member, and any changes in attitude that we see from

1 the contacts of the subunits of the Tiva Canyon Member.

2           These subunits are zonal variations, and these  
3 zonal variations include a wide range of attributes. These  
4 include differences in the groundmass devitrification. They  
5 include welding, changes in welding, the shape of the eroded  
6 surfaces, the texture of the subunits or the weathered  
7 surfaces making up the subunits, the abundance of lithophysae  
8 cavities and lithic fragments, as well as phenocryst ratios.  
9 Now, any of these attributes that are used in the mapping  
10 are basically the same attributes that were used in the  
11 1:12,000 mapping done by Scott and Bonk in 1984. However,  
12 we've refined it a little more in that we are able to see  
13 slight variations in welding and in many of these attributes  
14 that can be used to detect offsets that may be on the order  
15 of a couple of feet.

16           We then have taken all of these 61 areas that we've  
17 mapped, compiled them on a base map of one inch equals 50  
18 feet, or 1:600.

19           Back to our fracture mapping, we've managed in this  
20 area to map 745 fractures distributed throughout the subunits  
21 of the Tiva Canyon, the lengths varying from 6 to 85 feet.

22           This is an example of some of our slope that we're  
23 mapping here. This is the south-facing slope of Antler  
24 Ridge. Some of you have had the opportunity to visit this  
25 slope recently, and what we see here, looking to the north,

1 we can from Scott and Bonk's mapping at 1:12,000, you can  
2 pretty much pick out the main trace of the Ghost Dance Fault  
3 coming through here, offsetting the cliff-forming or Upper  
4 Cliff Unit here from the Upper Cliff Unit here. So the main  
5 trace is right through here. As you can see from this  
6 photograph, the area is pretty much partially covered, but  
7 when you get down on your hands and knees, you can see  
8 through part of the cover and identify other features.

9           For example, here, these areas here are what we  
10 would map as covered, and these peculiar features are rock  
11 slides of the Upper Cliff, presumably coming from this area,  
12 sliding down the slope. Other than these covered areas, most  
13 of the area is partially covered.

14           Well, in our detailed mapping, we have discovered  
15 more than just the main trace of the Ghost Dance Fault. What  
16 we've mapped out are several other north-trending traces;  
17 again, the main trace of the Ghost Dance Fault here, but in  
18 mapping the subunits and breccia zones, we've discovered that  
19 on either side of the main trace, there are several other  
20 faults that can be identified by offsets of strata, as well  
21 as breccia.

22           This particular outcrop here is roughly 250 feet of  
23 relief, and in our grid system, it would come out to about  
24 here. So it's about 600 feet this way. So in this, you'd  
25 note that there's about 50 feet of displacement along the

1 main trace of the Ghost Dance Fault. There are these other  
2 features where we identified offsets on the order of five to  
3 twenty feet.

4           Some of our preliminary findings, the fracture  
5 mapping indicates that there's a dominance of northwest-  
6 trending high-angle fractures. The trend is roughly north to  
7 north 10 west, and this particular pattern occurs throughout  
8 all the subunits of the Tiva Canyon within our study area.

9           The Ghost Dance Fault, as indicated by the previous  
10 slide, appears to be anastomosing a subparallel network of  
11 several north-trending faults, and these faults show minor  
12 displacement on the order of five to twenty feet, and if you  
13 take the width, or if you include this as some type of zone,  
14 then the lateral extent of the zone may be around 500 or 700  
15 feet.

16           With these preliminary findings, and in reviewing  
17 our maps, we have proposed several things for continuing this  
18 effort in FY93. The items include extending this type, using  
19 this type of mapping technique to extend northward to cover  
20 the entire length of the Ghost Dance Fault; to use this grid-  
21 attribute technique to also map a much broader area outside  
22 or farther away from the Ghost Dance Fault to compare with  
23 what we're seeing in straddling the Ghost Dance Fault. We  
24 would also like to attempt to apply this technique to  
25 selected areas along the north and south ramp, and in

1 addition to that, we have proposed that we augment this  
2 mapping technique perhaps by exposing the lowermost flanks of  
3 some of these ridges, such as Antler Ridge, to see what the  
4 character of some of these rock units look like, either  
5 clearing pavements or constructing some type of road cuts.

6           These proposals include these particular areas.  
7 This, in yellow, shows again our area completed in '92. We'd  
8 like to extend that and include the entire length of the  
9 Ghost Dance Fault, shown in green, to expand in both  
10 directions, east and west, shown in blue, and on also  
11 selected areas in the north and south ramp areas.

12           And just as some qualifying statements here, again,  
13 I reiterate that this data is very preliminary and  
14 incomplete, and at least at the present time, we haven't had  
15 the opportunity to do a complete analysis of our fracture and  
16 fault data, nor interpretation of that data; and also, that  
17 this structural information or this structural study was not  
18 focused in on the age determinations of the Ghost Dance  
19 Fault. Swadley and others had had at least one trench along  
20 the fault, Ghost Dance Fault, and three trenches along the  
21 Abandoned Wash segment, and as I indicated earlier, there  
22 does not seem to be any quaternary movement shown by those  
23 trenches; however, that does not negate the possibility that  
24 a trenching program also be initiated along segments of the  
25 Ghost Dance Fault.

1           Finally, I'd also like to reiterate that as far as  
2 our geologic mapping and development of the 3-D geologic  
3 model, that we certainly recognize that there's a need for  
4 both components, both the surface component as well as the  
5 subsurface component, and to get a high degree of confidence  
6 in the geologic model, you certainly need both to make the  
7 correlations of what you find at the surface, or what you  
8 find at the subsurface with what you see at the surface.

9           Thank you.

10          DR. ALLEN: Thank you, Rick.

11           One point of clarification, please; a couple. You  
12 state that Swadley, Hoover & Rosholt found no evidence of  
13 quaternary faulting, but as I understood it, they found no  
14 evidence to preclude quaternary, either. Is that correct or  
15 not?

16          MR. SPENGLER: Yeah, that is correct, in that the units  
17 that were actually sampled in those trenches--in my  
18 understanding, the units that they sampled in those trenches--  
19 -however, I'm not an expert in quaternary fault mapping--that  
20 the units weren't there to isolate the age of a fault.

21          DR. ALLEN: Okay. Although I don't mean to sound like a  
22 lawyer, but am I correct in saying that the recent work on  
23 the Solitario Canyon Fault, which is the next fault to the  
24 west--about a mile away, bordering the west side of the  
25 repository block, where there are quaternary units of young

1 age--we now have documentation of Holocene displacement on  
2 the Solitario Canyon Fault. As I understood it, that was  
3 true. Is that right?

4 MR. SPENGLER: Yes, that's correct.

5 DR. ALLEN: Okay. That's why I'm so concerned about--or  
6 why we're concerned about this fault, because if we cannot  
7 find evidence precluding late quaternary displacement,  
8 Holocene displacement on the Ghost Dance Faults and the  
9 branches, then that may put us in the rather difficult  
10 position of perhaps having to assume that there is, to be  
11 conservative.

12 Are there questions from the Board? Yes, Don?

13 DR. LANGMUIR: Langmuir; Board.

14 Another obvious concern we have is the potential  
15 for fluid movement along the faults. I wondered if Spengler  
16 or you people identified any kind of bleaching or coloration  
17 changes which would indicate fluid flow had occurred  
18 preferentially along the Ghost Dance or any of the faults  
19 that you've been able to see from the surface?

20 MR. SPENGLER: Yes, we have. In our mapping, we have  
21 also attempted to map any areas of alteration, or relative  
22 differences in alteration, and we do see some type of  
23 alteration. We attribute it, at least in the preliminary  
24 sense, to be vapor-phase alteration, or related to early  
25 cooling of the ash-flow tuffs, but the mapping out the

1 distribution of that alteration and doing any petrographic  
2 analysis basically remains to be done. All of this has been  
3 megascopic mapping.

4 DR. LANGMUIR: So you can't tell whether the fluid was a  
5 vapor rising or water going down to the system by  
6 infiltration?

7 MR. SPENGLER: No.

8 DR. LANGMUIR: That's something you'll be looking at.

9 MR. SPENGLER: All we've done at this point is map out  
10 relative areas of alteration.

11 DR. ALLEN: Ed Cording?

12 DR. CORDING: I'm pleased to see the program for looking  
13 not only along the Ghost Dance Fault this next year, but also  
14 areas away from it to get some real details in typical areas  
15 that perhaps are away from the Ghost Dance. I think that  
16 will be very valuable information, and then, also, the  
17 surface information along the ramps. When that's combined  
18 with, ultimately, underground information, I think it'll be  
19 an important picture to see both the surface and the  
20 underground information.

21 MR. SPENGLER: I think this detailed mapping 1:240,  
22 which is nothing new to the mining industry. That's  
23 something they routinely do as far as the mapping mining  
24 claims, as well as open pit mining, so our attempt was get to  
25 a scale that would at least be similar to a scale that could

1 be used to the underground mapping, and use that as a  
2 correlation tool.

3 DR. CORDING: Exactly; yes.

4 DR. ALLEN: I would also urge that we make another  
5 attempt to define localities, particularly in the southern  
6 branches of the fault where it goes out into those alluvial  
7 valleys, to see if there isn't some possibility somewhere of  
8 telling something about the age of movement, because this may  
9 turn out to be quite critical in terms of, you know, a fair  
10 segment of the repository block.

11 Staff?

12 (No audible response.)

13 DR. ALLEN: We still have a couple more minutes. Any  
14 questions from the audience?

15 (No audible response.)

16 DR. ALLEN: Okay. Thank you very much, Rick. We  
17 appreciate being brought up to date.

18 Let me turn the meeting back over to our Chairman,  
19 John Cantlon.

20 DR. CANTLON: I thank you.

21 Our next speaker is John Bartlett, who's going to  
22 give us some introductory remarks.

23 John?

24 MR. BARTLETT: It seems rather odd to have the third  
25 item from the end of a two-day agenda labeled, "Introductory

1 Remarks." Consequently, what I'd like to start with are some  
2 summary remarks, if I might. I would like to make some  
3 comments relative to what I heard earlier today, and since I  
4 have the benefit of ignorance, not having been here  
5 yesterday, I feel free to address only the limited area that  
6 I did have an opportunity to listen to, and what I'd like to  
7 do is give you something of a, needless to say, a management  
8 or director's perspective on some of the issues that were  
9 addressed by the presentations, and by Dr. North's summary,  
10 and the critiques from the consultants and the like, because  
11 I think they're vitally important to the program.

12           I think it's obvious, probably, to you--not  
13 probably, I'm sure it's obvious to you--from the  
14 presentations you've heard that the technical issues  
15 associated with near-field matters associated with the  
16 repository are, indeed, a very rich and fertile load of  
17 opportunities for technical activity, and this raises, in the  
18 Director's mind, a very important issue, and that is to  
19 distinguish the possible from the necessary.

20           The array of possible, technically possible, is  
21 just enormous. The key issue for management of the program,  
22 defense of the program in the external arenas is what's  
23 necessary among the possible, and the key question there is,  
24 how do you determine what's necessary, and how do you defend  
25 that determination?

1           And basically, the strategy we would use--I used to  
2 do that--is to look ahead, of course, as to what information  
3 is necessary for the regulatory arena, regulatory compliance.  
4 And then that gets into the second order question, which is  
5 basically, how do you convince the regulatory arena that what  
6 you have defined as necessary is, indeed, the necessary; that  
7 you have made the proper selection of the array of the  
8 possible; that is, the information that's appropriate for the  
9 regulatory arena? Because, as you heard today, the array of  
10 possibilities that can be identified by the regulatory body  
11 is of a comparable magnitude to that that can be identified  
12 within the program itself.

13           So what we try to do is look ahead to the  
14 regulatory arena, make our estimate of what is necessary, and  
15 then the question becomes: Can you demonstrate that what you  
16 have defined as necessary is, in fact, that, without doing it  
17 all to prove that that was what was necessary? Very  
18 challenging question.

19           My answer to that is the way you do it is through  
20 such things as use of expert judgment and performance  
21 assessment, and I was delighted to hear Dr. North use my  
22 phrase, "engine of evolution," because that's exactly what  
23 it's all about. We're evolving that, and I'll talk about  
24 that in a couple of minutes in my introductory remarks. But  
25 fundamentally, that's where that comes into play, is in the

1 process of exercising performance assessment expert judgment  
2 and the like for purposes of selecting and defending the  
3 necessary work for the program from among the range of  
4 possible activities, and that's one of the things we will be  
5 focusing on in the future.

6           I'd like to comment very briefly on a couple of  
7 other things I took notes on. Bob Shaw made the comment that  
8 he thought maybe the CCDF would go away if the regs are  
9 changed. I don't think it'll ever go away, because it will  
10 pop up inevitably, even if you have a dose standard rather  
11 than a probabilistic standard. It'll pop up in the  
12 regulatory compliance demonstration inevitably, because the  
13 compliance demonstration process will inevitably be  
14 probabilistic in itself, and the CCDF is a tool for that no  
15 matter what the standard is. You might have different things  
16 on the grid, but you're still going to be using the same  
17 method of analysis for demonstration of compliance.

18           There's another thing. I'd like to offer you an  
19 opportunity to win. There was commentary about the universal  
20 canister, and there was an oblique comment that that's not  
21 the right phrase. It sure isn't. There's a history of use  
22 of that where the concept is a single canister that does  
23 everything, and it's used to pick up at the reactor, to  
24 transport, to store, and then to dispose. That's not the  
25 concept I want to emphasize. What we're talking about is a

1 relatively lean and mean beer can or something of that nature  
2 that the spent fuel would be put in at the reactor, and then  
3 that has sleeves that would come and go, depending on what  
4 the function is. You put that into a transport cask, for  
5 example; remove it from the transport cask, put it into,  
6 perhaps, something else for intermediate storage, perhaps  
7 something else for disposal. That's the concept.

8           The trick is, the opportunity to win is, name that  
9 concept. Get away from the phrase "universal canister." We  
10 need to get away from that, because it's almost pejorative,  
11 and it certainly has a history that we don't want to  
12 associate with that.

13           Let me turn now to the introductory remarks. I  
14 think you're certainly all aware of the fact that we inside  
15 the beltway are just coming off a very intense period of  
16 activity, wherein the Congress passed, in relatively short  
17 time frame, the Energy Bill, the WIPP Bill, and the Energy  
18 and Water Appropriation Bill, and let me make first a couple  
19 of remarks about the Energy Bill.

20           Within that, of course, the most significant aspect  
21 of it for our program is Title 801, which dealt with the  
22 disposal standards. It called for the National Academy of  
23 Sciences to do a scientific study as a basis for promulgation  
24 of standards through the EPA and the NRC. It set a schedule  
25 for that, and basically, the most important thing about it,

1 it will convert under law now the type of standards used for  
2 the program from performance-based release from the  
3 repository to dose-based, which is the approach to regulation  
4 that's used throughout the rest of the world.

5           The thing I want to comment on here for emphasis is  
6 there's been a lot of press comment and the like that this  
7 will relax the standards. There is no implication whatsoever  
8 in the legislation of an impact on the stringency or whatever  
9 of the standards. What that will turn out to be depends on  
10 what comes out of the process that's been set up by the Act.  
11 They could be more stringent. They could be more relaxed,  
12 although that's a very hard equation to make, because to get  
13 a relationship between the performance of a repository, the  
14 release and the dose standard is, in fact, a very difficult  
15 thing. So I think it will be very difficult to say it's  
16 going to be more relaxed or it's going to be more stringent  
17 or whatever. Frankly, I think that's an irrelevant issue.

18           What does need to come out of it is appropriate  
19 standards to assure the public health and safety for  
20 disposal, and I think with the process that's been set up,  
21 the opportunity is there with a scientific base from the  
22 Academy, and the public processes, that the EPA and the NRC  
23 have to use to promulgate the standards, will be that we will  
24 get out of the process with what I certainly hope will be  
25 appropriate standards for disposal safety.

1           Let me turn now to the budget aspects. Very  
2 simply, again, I think you're all aware that the Congress  
3 appropriated for Fiscal Year 1993 for our program \$375  
4 million. That's a \$100 million increase from last year, and  
5 basically, Carl took it all.

6           (Laughter.)

7           MR. BARTLETT: He's going to tell you how he's going to  
8 spend it.

9           I would inform you today that I cannot say anything  
10 whatsoever about funding beyond the current year. As a  
11 matter of fact, the Department has not even submitted its own  
12 proposal for Fiscal 94 funding to the OMB yet, and of course,  
13 the internal budget process within the Administration goes on  
14 without essentially public process until the budget is  
15 submitted by the President to the Congress next January. So,  
16 frankly, I have no idea what the budget will be beyond this  
17 year, but you will hear from Carl the details of how the  
18 expenditures are expected to be used with respect to the  
19 Yucca Mountain Project this year.

20           I'd like also to comment briefly on three things  
21 that we have underway within the program, basically in  
22 support of the work activities for Yucca Mountain. These are  
23 not new to you, but I would like to underline them and  
24 emphasize them.

25           First of all, we have underway an assessment of

1 opportunities to revise the work activities associated with  
2 the Yucca Mountain Project. We have been working since 1988  
3 to the specifics of the site characterization plan. As a  
4 result of data acquisition and interpretation since then, we  
5 now have a better idea of what might be done in the future,  
6 and we are in process of using that information we've  
7 acquired to determine if there are revisions to the original  
8 work plan that might be beneficial.

9           The tools of the doing of that are the early site  
10 suitability evaluation report, which was issued to the  
11 Department by our contractors, and to the public for review  
12 back in February; the total systems performance assessment  
13 report that was issued in July; and an ongoing effort which  
14 we call integrated technical evaluation, which is looking at  
15 the interactive aspects and opportunities for prioritization  
16 in the various technologies working within the Yucca Mountain  
17 Project. All of this will be brought together for an  
18 assessment of potential revisions to the work activities, and  
19 we expect to complete that early next year.

20           We are also developing, as part of our program plan  
21 activities, and a public exposition of our activities, a  
22 series of program milestones associated with evaluation of  
23 site suitability. I'm sure you're all aware that we have  
24 been historically focusing on the 2001 date for submission of  
25 license application to the NRC if the site is found suitable.

1           There are several reasons of history for that  
2 focus, not the least of which is that that's the date set by  
3 the Secretary's plan, and it also is the target date for the  
4 overall planning of the Yucca Mountain Project activities,  
5 and so what we are doing now is building into the time space  
6 between now and that point in time, specific performance  
7 milestones for communication, with the Board and with others,  
8 with regard to progress in evaluation of the suitability or  
9 unsuitability of the site against the criteria for site  
10 evaluation.

11           So we will be presenting again in the near future  
12 what amounts to a more detailed program plan which shows you  
13 the basis for, and includes these milestones, essentially  
14 which will be related to topical reports of findings relating  
15 to the technical issues associated with suitability.

16           One other thing that we're doing is continuing our  
17 effort to assure effective management of the project. Engine  
18 of evolution started it. You may recall in a previous  
19 presentation to the Board, you heard from the M&O about  
20 convergence, and you'll recall the sideways ice cream cone  
21 diagram where we had the various activities converging on the  
22 products of site suitability findings and environmental  
23 impact statement license application if the site is suitable.  
24 We are converting that into a management action plan, and no  
25 surprise, under the title, internally, of "Convergence." And

1 we have that actively underway to assure that we have the  
2 right things underway and active to implement the engine of  
3 evolution, and that we have the right performance assessment  
4 tools for the engine, et cetera. And so that's the framework  
5 under which Carl was working, and I'll ask Carl now to talk  
6 about, specifically, the activities for the coming year.

7 MR. GERTZ: John, thank you very much. It's always a  
8 pleasure to follow your boss, and then be assured that I'm  
9 pretty consistent with what he said. So I'll enhance on some  
10 of the things John said, including the particular budget, and  
11 I will tell you a little bit about what we think it takes to  
12 do the job in the out year. Whether that is part of the OMB  
13 submission, is another question, but it's a part of our 2001.

14 So I'm pleased to be here. I intend to talk maybe  
15 for 40 minutes or so, and then take any questions you might  
16 have as long as you might have. I notice we're last on the  
17 agenda, so I'm here as long as you all want to talk about it.

18 I'm going to start off with "focus of the program,"  
19 where we've been focusing in the last year. I'm going to  
20 talk about some '92 accomplishments and the '92 budget so you  
21 can see where we're going in '93, and I'm going to spend some  
22 time on the '93 activities, and then address challenges and  
23 issues, some of which John already addressed.

24 This last year, in '92, we've tried to conduct the  
25 maximum amount of site geological investigations, tried to

1 find out physically, gather data about suitability or  
2 disqualifiers, and our focus was to design the initial ESF  
3 activities; field work represented by activities like this,  
4 soil pits, drill paths, et cetera. It's underway. You'll  
5 see lots of that tomorrow.

6           Design work represented by a concept for the ESF  
7 where we've designed this type of facility and the first 200  
8 feet of trench. Our goal in '93 is to build that design, to  
9 build that design and be ready to order a TBM and be ready to  
10 put a TBM in at the end of the starter tunnel. In '93, we  
11 want to continue gathering field data, address our  
12 environmental program and our outreach program, and  
13 monitoring and other site surface-based testing.

14           In '93, our goal is, in a simple cross-section, be  
15 a couple of hundred feet into the mountain. That drill pad  
16 you saw on the last view graph will be taken down. We'll  
17 have a new pad for the ESF, launch chamber, starting tunnel,  
18 call it what you want. Hopefully, a year from now or so,  
19 that's what it'll look like. The TBM won't be there, we  
20 don't think--I'll show you a schedule a little bit later--but  
21 we hope it'll be on the way at that time. The first 200 feet  
22 will be drill and blast.

23           I'll give you some of the bottom lines first. I  
24 need to just give you a little summary. There are some  
25 people in the audience who may not be familiar with the

1 program, so I won't bore you to death with it, but certainly,  
2 everything we're doing was created by Congress. They told  
3 DOE to do the job. They set up a extensive suite of  
4 regulations, including standards by the EPA--and John  
5 addressed the update of that--regulations that we need to  
6 meet by the NRC, Department of Transportation for  
7 transportation, and they created a regulatory role for the  
8 State of Nevada, not only through current EPA and other flow-  
9 down areas, but also, they can veto the site after the study.  
10 That veto can be overturned by both houses of Congress.

11           They also created an extensive suite of oversights.  
12 I'll expand on that a little bit. This is one of the  
13 oversight activities. I've said it publicly before, and I'll  
14 say it again. I think when Congress said, "Study only Yucca  
15 Mountain," it was a stroke of genius in creating the Nuclear  
16 Waste Technical Review Board. It provided independent  
17 oversight; allows us to go to the public and say, "Not only  
18 are we licensed independently, but we have an independent  
19 Board chosen by the President to oversee our program."

20           Excuse me, one more thing. One more thing that is  
21 now coming to light a little bit in the state is that there  
22 are benefits available not only specifically in the law--a  
23 lump sum or impact assistance--but the state could work with  
24 a negotiator, to negotiate whatever role in the management,  
25 in the operation, in the safety, in the overview, along with

1 financial benefits if they so choose. The state, at this  
2 time, has chosen not to pick up on that option. They've  
3 remained adamantly opposed at the political levels.

4           Talk about oversight. Here it is, and this is no  
5 small part of a cost of doing business on the project. We  
6 have the Congress, we have the NRC, we have you all, we have  
7 the EPA, we have OMB. I spent seven hours with Steve  
8 Goldberg and my staff going over the project on oversight  
9 with OMB on Monday. We have the utilities who are  
10 represented here by EEI, EPRI is involved, NARUC spent an  
11 extensive amount of time out here a month ago. The State of  
12 Nevada has three entities. Many of those--some of those  
13 people are here. They have the Waste Project Office, headed  
14 by Bob Loux; an agency of the Governor, the Commission on  
15 Nuclear Projects, headed by former Governor Grant Sawyer; and  
16 a legislative committee, and I think three of those members  
17 are in the audience today.

18           We have other affected units of local government.  
19 They're here today. The National Academy is involved with  
20 the permanent Board and some ad hoc boards, the most  
21 prominent of which has been the coupling effects one  
22 relatively to Jerry Szymanski's theory.

23           The GAO, they spend a lot of time with me. They  
24 write a lot of reports about the program. They're coming in  
25 next week for another week with us. The IG looks at

1 different aspects of the program. We've had the Secretary of  
2 Energy's Advisory Board on Trust and Confidence out here for  
3 hearings and in other parts of the country, and Department of  
4 Interior, through the Parks Service, Fish and Wildlife, and  
5 BLM, and I can go on and on, but these are the major ones,  
6 and I thought it was important to point out to you that  
7 that's a lot of our customers. That's a lot of points of  
8 views that we need to meet and talk to about.

9           With all that oversight, and with everything else,  
10 we do have momentum, though. Field work is underway. Our QA  
11 program is in place and it's working and the scientists and  
12 QA professionals are working. Our technical baseline is in  
13 place and accepted, as John points out. It is the SCP. Can  
14 it be changed? Absolutely, it can be changed. With proper  
15 rationale, we can add or subtract tests from that.

16           Cost and schedule control system. I'll talk more  
17 about that, but we have a sound cost and schedule control  
18 system that withstood 16 months of an IG investigation, along  
19 with the almost monthly, GAO looks at it.

20           We have drilling equipment in place, as you're well  
21 aware. We have a construction management team on site in the  
22 form of the M&O, and the M&O, of course, has moved into  
23 transition with other activities here, too. We have major  
24 permits in place, and the state continues to process  
25 applications in a timely manner. The state is not holding us

1 up at this time, and we have critical milestones that have  
2 been met.

3           Required funding? Well, we're somewhere in the  
4 check. We got more than we got last year, but we don't have  
5 what we think is enough to keep on the schedule in the out  
6 years, and I'll talk more about that in the future. But we  
7 do have momentum, and you'll see some of that tomorrow when  
8 you're out there.

9           Let me talk now about the accomplishments, and I'm  
10 going to go through these very briefly because I only want to  
11 set the stage for the other ones, and we'll do this with two  
12 things.

13           You're well aware we have the LM-300. We've built  
14 the pad, and we're on site drilling. Some you may not be as  
15 much aware of as Alan Flint's activities. They have  
16 completed 17 drillholes, seven more and we'll be finished  
17 with that program then we'll do our analyzation. Dr. Flint  
18 will talk to you a little bit about that tomorrow. Alan's  
19 using two different-type rigs.

20           We have an extensive amount of soil pits. You  
21 won't see all these tomorrow, because they're filled up. We  
22 got the data, and have filled them up, but that's out in  
23 Midway Valley. Right in there will be our entrance into  
24 Exile Hill, almost right into the picture, a little bit off  
25 to the right, for the tunnel.

1           In Midway Valley, of course, we're doing trenching,  
2 seeing if we have any hidden faults in the area. More of the  
3 soil pits, other trench-type investigations, that is an  
4 engineering soil pit, and this was our drilling on NRG-1.  
5 Now, although it's part of site characterization in our  
6 classification, it really is ESF work, because we're trying  
7 to find out the engineering properties below that drill path  
8 so we can design the tunnel.

9           We did some environmental drilling. We called it  
10 JF-3. That, of course, is complete. Our monitoring plan is  
11 in place and, in fact, as I'll point out later, we had a  
12 supplemental water permit from the state after our initial  
13 one for a 300 per cent increase in water. So, in effect, we  
14 have all our permits.

15           Other work that's going on, many of you were on the  
16 volcanism field trip of 40 excavations. Forty-five  
17 excavations were completed by Bruce Crowe. A long trench was  
18 completed in the Lathrop Wells area for scientific  
19 investigation.

20           So I want to point out, you'll see some of it  
21 tomorrow, you may not see all of it, but lots of work's going  
22 on.

23           Some of the things you don't see by the physical  
24 work, though, is our interactions with the Regulatory  
25 Commission. You all see the interactions with you all.

1 They're extensive. It's been an excellent three days today,  
2 or two days, and tomorrow will be the third one. We've had  
3 increased interactions with the Advisory Committee on Nuclear  
4 Waste. They're here next year--next week, excuse me--and  
5 they're going to go through some of the same stuff that we've  
6 gone through, including this kind of presentation, and we  
7 have been working towards closure by preparing an annotated  
8 outline. We've transmitted one for the NRC. The second  
9 revision to that is on its way.

10           What is driving the program? Boy, that's tough for  
11 a project manager to figure out what the priorities are. We  
12 are using performance assessment to identify some of those  
13 things. I think it was an excellent product, our first total  
14 systems performance assessment. We looked at many things.  
15 We did happen to publish some older performance assessments  
16 this year, too. We documented a number of performance  
17 assessment codes, and the other major product this year was  
18 the early site suitability. That helps focus the program.  
19 Where do we need to gather more data?

20           Certainly, these are both available. I hope you  
21 all have your own copies of these. They're available to the  
22 public, and this one, of course, evaluated DOE siting  
23 guidelines, came up with the 13 to 17 disqualifying  
24 conditions are not present, and probably additional data  
25 would not change that conclusion. Four of them are not

1 likely to be present, but we need some more data.

2           As to the rest of that site suitability, we talked  
3 about the qualifying conditions, and at this time we believe  
4 13 were present, and additional data is unlikely to change  
5 that, and 19 are likely to be present, but we need further  
6 information.

7           The bottom line of this report: How is it being  
8 used by DOE? Well, one, it's going to help us set  
9 priorities, and the ongoing activity of this, the test  
10 evaluation, integrated test evaluation activity results from  
11 this. But the bottom line is, it supports continuing site  
12 characterization. There's no reason to not continue site  
13 characterization based on a re-review of the data, and  
14 performance assessment was used in that, and it was peer  
15 reviewed, as you're aware.

16           Just to give you a little check, in '92, I think a  
17 year or so ago I talked to you about what we were going to do  
18 in '92, what was my 12 or 13 priorities. We had hoped to do  
19 the early site suitability evaluation report. We did do  
20 that. We did do this kind of work, and I showed you that on  
21 the view graphs. We did continue surface-based monitoring of  
22 52 seismic stations, monitoring of rainfall, monitoring of  
23 groundwater.

24           We did begin and complete the Title II design for  
25 this one package that I'll talk to you about. Our quality

1 assurance program remained in place with hundreds of audits;  
2 be it by the participants by Don Horton's oversight  
3 organization. As I pointed out, though, I think we really  
4 have a cooperative environment established between the  
5 quality assurance people and the professionals; scientists  
6 and engineers, so that we're doing what is necessary, and  
7 that's about it.

8           Maintained a sound environmental program. In this  
9 day and age, when you have a big project, you are burdened  
10 with RCRA and CIRCRA, and other Acts and other laws, be it  
11 cultural resources. We live in a fishbowl in this project,  
12 and we have to make sure we're complying with all those  
13 activities. As a matter of fact, right now Russ Dyer was  
14 telling me that one of our activities is bigger than most of  
15 the excavations you saw. It's 20 feet deep and 60 feet long  
16 and 40 feet wide, and it's digging up an old oil spill and  
17 hauling that soil off site, and that costs money, not only to  
18 haul it off site, but to dig it up. But that's a spill we  
19 created in '78 or the eighties, but we're responsible for  
20 cleaning it up as part of RCRA.

21           And we're implementing a sound cost schedule  
22 control system. It pleases me that the scientists and  
23 engineers know about what the costs are, what about the  
24 schedule, whether they're behind or ahead of schedule, are  
25 they meeting their goals, are they meeting their milestones.

1           On the other hand, we only had a very minimal waste  
2 package EBS near-field environment waste form  
3 characterization program. We didn't do much last year. You  
4 were able to see some results. Some of the results were done  
5 by EM's program the last couple days, but we didn't have much  
6 money there. We did maintain our roads, buildings, and  
7 record centers. We conducted an institutional and outreach  
8 program that we think appropriate for the activity going on,  
9 and we brought on the M&O and they transitioned to the major  
10 project activities, the roles of integration, the roles of  
11 project direction.

12           I'll talk to you about permits. As I pointed out,  
13 in order to make progress in the field, we needed the state's  
14 cooperation. We received permits fairly regularly throughout  
15 the year. The most recent one was additional groundwater  
16 appropriation. Although we had a nine-day hearing back here  
17 in January for our first water one, we received 300 per cent  
18 more water without any hearing. It was based on the previous  
19 hearing. So we hope this will continue and we're pleased  
20 with the professionalism of the state at this point.

21           John alluded to this, and he pointed out some of  
22 the things that are on my chart. Now, I don't know if he  
23 read my chart before I put it up here, or it's stuff we've  
24 been discussing all the time, but Congress is concerned about  
25 reducing overall program costs. They don't like the idea of

1 spending so much money to study a site. So what actions have  
2 we completed to address this?

3           Well, we have completed an independent cost  
4 estimate of the work in place. You've got to know your  
5 baseline and what we've agreed to do and what that costs  
6 before you can change it. That's not "we," that's other  
7 elements of the Department. It was done by independent  
8 architect engineers within other organizations of the  
9 Department.

10           We undertook the Mission 2001. It was headed by  
11 Dale Foust's M&O team. It was to look at: what does it take,  
12 let's do a scrub of what it takes to do the work; and can we  
13 get it done by 2001? We wanted to validate the estimate. We  
14 wanted to make sure we could meet the schedule under our  
15 current funding, what we got last year and the year before.

16           We did do the early site suitability report. That  
17 helps us focus. Scientific tests are being prioritized, and  
18 we hope, through issue closure, to eliminate some tests from  
19 our suite of tests in the SCP. So that's some actions that  
20 are completed.

21           In the planned-what I'm trying to remind everybody,  
22 cost consciousness is everybody's responsibility, much like  
23 safety, and much like QA. We have to step up, we have to be  
24 professional, and say, "Is this necessary?" Just the things  
25 John pointed out. Not, "Is it nice to do" and "Would it

1 really be great to do a paper on it," but is it necessary for  
2 program success.

3           We have established our 2001 baseline. We've had  
4 some recommended cuts to that. I'll talk to you about it.  
5 I've asked my technical project officers to meet with me here  
6 in October and see if we can brainstorm and can up with some  
7 other top down approach to this plan. Then we'll formalize  
8 our baseline with the '94 Passback, we'll probably  
9 incorporate some top down reduction, and as John pointed out,  
10 we'll start to develop a list of candidate activities,  
11 specifics for cost reduction. We want to lay out specific  
12 activities, get with our Regulator, and say, "Can we take  
13 these out of the plan?" And, really, that's one of the  
14 challenges that we have.

15           We have a mechanism for doing that; either the  
16 semiannual progress report, a topical report, issue closure  
17 activities. That's where we're heading with this particular  
18 activity. As I said, there is a mechanism.

19           Let me now step back a bit to put things in  
20 perspective. We've talked about the \$6.3 billion baseline.  
21 It's approved by the Energy Systems Advisory Acquisition  
22 Board. It includes 20 years of activity, from '83 to 2002.  
23 It included total costs for site suitability and license  
24 application, if suitable. It had actual costs in it of about  
25 this much, \$1.3 billion. It had some unescalated state

1 payments to the counties. We anticipated there might be a  
2 benefits agreement, so we put in that estimate, about \$800  
3 million for oversight and benefits, and PETT payments,  
4 payment equal to taxes. We also put in that estimate  
5 escalation, which left about \$3.6 billion of unescalated  
6 direct project work to be done.

7           So when you say \$6.3 billion, well, that's one  
8 number. Here's the amount, unescalated, to do the work from  
9 now to 2001. These are very broad. They're only meant to be  
10 put in context for you, but site investigations, trenching,  
11 drilling, ESF testing, the scientific investigation, almost a  
12 billion; build an ESF and operate it. The testing's up here,  
13 the building's down here of an ESF, about a billion.

14           Waste package and repository design, you have to  
15 have designs to support license application; \$500 million.  
16 The systems engineering, the technical data base, the  
17 performance assessment, we happened, in this category, to put  
18 in environmental and institutional support, \$600 million; and  
19 then the project management, training, records management we  
20 put here. That's how that \$3.6 billion comes up.

21           Now, we've got a well-detailed, according to our  
22 work breakdown structure in what we call our Mission 2001,  
23 and you'll see how that comes up a little bit later, but I'd  
24 like to point out about the independent ICE results.

25           As I said, they've issued their report just a month

1 ago. It's very current. They said our approved baseline,  
2 which was in the \$6.3 billion range, represents a reasonable  
3 value for the currently-planned work. It's an adequate  
4 baseline for the project. They looked at cost rates, they  
5 looked at labor rates, they looked at everything they could.  
6 They believe that license application in 2001 is achievable,  
7 providing adequate funding is received. They found no  
8 technical obstacles. They believe proposed staffing and  
9 capital equipment ramp-ups can be accomplished in the out  
10 years to meet that.

11           They also made a comment that we could be more  
12 success-oriented if taken off budget. Now, I have a little  
13 star--Steve Goldberg said off budget is not the right word;  
14 try "improve budgeting process." This happens to be the word  
15 they used, whether it's a revolving account, whatever the  
16 right word is, but they said, you're going to need something  
17 like that if you're going to assure availability of adequate  
18 funding. They said the transition to the M&O should be  
19 reviewed to make sure there's no duplication. We're sure  
20 trying to do that. The M&O is working with us on that. And  
21 they said we, the federal staff and the M&O, need to define  
22 the scope and requirements for this waste package and  
23 repository design, because we're going to be producing a lot  
24 of paper at a lot of money, and is that what's really  
25 necessary for a license application. That's just paper,

1 license application, designs for waste package and  
2 repository. So that was their results.

3           This was how we spread our money in '92. That's  
4 how we spread it and, in effect, spent it. That's just there  
5 for your reference. That's how it was.

6           I'll talk about the Mission 2001, because this is  
7 our baseline plan. It's in the book. The numbers get small,  
8 but I wanted to put it all on one page. This line across the  
9 bottom is what we predicted our spending would be, \$6.1  
10 billion, in order to meet a license application in 2001. The  
11 line below that is what the ICE predicted our funding should  
12 be to get to a license application; fairly close on the  
13 number, up and down at different years, up and down in  
14 different categories, but overall, we spent a lot of time  
15 with them reviewing this estimate, but you can see right off  
16 the bat--and I'll tell you in a minute--that's not what I'm  
17 going to spend in '93. John has not allocated that much of  
18 the \$375 million.

19           We still think we can meet 2001, even with what we  
20 have in '93, but we're going to take some big jumps in '94 if  
21 we want to do the current program under the current schedule.  
22 There's footnotes to that, but you can look at it.

23           Now, this is not a chart I use to manage anything  
24 by, but it's a chart I've discussed with you all, at your  
25 request, about how the funds are broken out, so it's not my

1 detailed accounting system, but I want to put it up here to  
2 make some points.

3           If you recall, we discussed, in your definition,  
4 real work, per se, was called drilling or gathering data, and  
5 designing things. Everything else, performance assessment or  
6 whatever, we considered a foundation to do the other work.

7           Last year, we had 33 per cent above the line and 67  
8 per cent in the foundation. This year, with this kind of a  
9 budget, \$245 million, we're 56 per cent below the line. We  
10 reduced our percentage, and increased our percentage above  
11 the line, and the big swinger, of course, is exploratory  
12 shaft. So I think we're heading in the right direction. We  
13 did have an estimate that was almost 50-50, but that was of a  
14 \$321 million approach.

15           So that's some broad categories. As I said, don't  
16 try to track this. It's not our WBS. It's just a broad  
17 picture for you all to show what we agree what we think is  
18 above the line in this breakdown, and what's below the line.

19           We also provided for you a detailed list of what  
20 was below the line and where was that on that chart, and this  
21 is in here for you. This is how we spread it last year, and  
22 let me tell you, the GAO comes in and they debate with me  
23 about what should be above the line and below the line. EEI  
24 comes in, everybody debates about this distribution. You can  
25 make any distribution you want. It all depends upon

1 definitions, because we don't manage it this way. That's  
2 just a listing of those costs.

3           And in '93, that's a listing of the costs, which  
4 leaves about \$107 million above the line to do scientific and  
5 technical activities. I say preliminary, because I have not  
6 finalized this spread to my division directors and my  
7 participants. We've had a lot of meetings. We've had three  
8 full days of back and forth on how much. Let me go ahead.

9           Although we're at 244.7, when I told everybody what  
10 the priorities are and what the target was, the first input  
11 of numbers I got was over 300 million from everybody, and  
12 that was not to do what they'd like to do, but what they  
13 thought was necessary for '93.

14           This is our work breakdown structure. It's in the  
15 book. As you well know, we have lots of accounts. We now  
16 have 15 elements across the top. We're going to emphasize  
17 ESF and site investigations next year. I just wanted to show  
18 you that's up there. Put up the other part of it; I'm sorry.  
19 That's the other 15 elements. You can read them. That's  
20 how we manage the work, and let me point out what that  
21 consists of:

22           Below that, for each participant, for everybody, we  
23 have 816 planning and scheduling accounts, summary accounts  
24 below that, that's eight participants, 44 minor participants,  
25 this many activities. They're all scheduled out. They're

1 all resource-loaded for next year. They report against  
2 milestones in each of these accounts. I'll show you how that  
3 works.

4           We just happen to have Rick Spengler here, and it's  
5 one of his accounts, and this was last year's, but as you go  
6 down the account--go back to the big one first before I get  
7 to it. I'm just going to expand this one little box. That's  
8 geology, at the fourth level under site. As you expand that,  
9 geology has a person responsible for it. Some of these names  
10 have been changed. It goes down to different people;  
11 Raytheon doing some things, USGS doing some things, REECo  
12 doing some things.

13           In Rick's area at USGS, he then has some summary  
14 accounts, and in case you're wondering, inside the summary  
15 accounts there's ten activities, total up to \$500,000; 14  
16 activities here, seven activities here, seven activities  
17 here. So we manage, plan, and report at a fairly low level.  
18 That's why we can survive audits. That's why I can stand up  
19 honestly and tell everyone I know where the money's going,  
20 and we do this with national labs, we do this with the USGS,  
21 we do this with all the contractors. That's across the  
22 program.

23           Does it cost money to implement this kind of a  
24 cost-control system? Yes, it does. Is it worth it?  
25 Absolutely, in my mind.

1           Here's where we come down to the real '93 now. Now  
2 is where the fun kind of starts, because nobody likes these  
3 numbers. Everybody thinks they don't have enough to do what  
4 is necessary for next year. We have 245 million. Here's how  
5 I've spread it through the 15 work breakdown structure items.  
6 Vince Iori and the M&O team that supports him have worked  
7 hard with my division directors trying to get the best split.  
8 I still have some ongoing meetings, because people have  
9 said, "I can't do what's absolutely necessary," and so I  
10 still may have to adjust this a little bit. I hope not too  
11 much, but that's how we've spread it.

12           I'm going to go through each of these 15 items so  
13 you get an idea where we're going, but I need to do one other  
14 thing, because, as I said, we had three days of meetings. I  
15 asked everyone to come in and tell me what they could do. I  
16 gave them a bogey number, so to speak, a planning number, and  
17 I thought it'd come out around 250 and I could handle that,  
18 and it came out around 300. And some of you know, I have an  
19 avocation that involves sports officiating. Well, it's  
20 pretty chaotic during a football game sometimes, and it was  
21 pretty chaotic during these budget meetings, and I'm not sure  
22 if Russ Dyer, Larry Hayes, Ardyth Simmons, if anybody's happy  
23 with the kind of money they get.

24           Ace, you know, is going to run some tours, but he  
25 said, "I can't do all the tours that you want me to do." The

1 schools are calling up. They want to come on tours, and I  
2 may not have enough money to take the kids out to the site,  
3 so it's a challenge, splitting out this money, because that's  
4 not enough to do what we think is necessary, but we'll do  
5 what we can do this year and put the rest off to next year.

6           Let me tell you how we're going to use that money,  
7 and I'm going to go through each WBS and talk about what  
8 we're going to do for the money. I tried to limit most of  
9 them just to one page. There is backup detail for you in the  
10 book if you want. We're going to have reams of data. Our  
11 PACS system is about this thick. I think Russ McFarland  
12 asked for some of it for estimating. I think he can  
13 attribute it to you. We went through in some detail with OMB  
14 on Monday about the system.

15           But we're going to ESF site preparation, and we're  
16 going to construct the first 200 feet of the north portal and  
17 ramp. That's our goal. I'll show you a schedule for that in  
18 a second. We're going to continue the rest of the design.  
19 We have to design some more of the ESF, the next stop, the  
20 next part of the ramp. We're fast-tracking. There's no  
21 doubt about it. We don't have an ESF design complete. We're  
22 designing it in segments because of our funding restraints.  
23 We've got to prepare facilities for ESF testing. The first  
24 200 feet is going to have an alcove in it for testing.

25           We need to award a subcontract for underground

1 construction. We wanted to find the world's best underground  
2 constructor. We went out for bids, we got proposals. There  
3 were some modifications that needed to be made to those  
4 proposals, so we didn't want to lose the bid process, that's  
5 the bottom line. So we had to go out for proposals again.  
6 It probably won't be until January until we award this  
7 underground construction. That doesn't affect the first 200  
8 feet, because REECO's going to do that with force account by  
9 drill and blast. This is for the 14 miles or so of tunnels.

10 We hope to issue the RFP, receive proposals, and  
11 award a contract for first large TBM and support equipment.  
12 We want to do that next year. We need to upgrade our power  
13 so a TBM can operate, and I'm going to show you some pictures  
14 and some schedules about the ESF. I'm going to concentrate  
15 on the ESF this afternoon. It's in the book, but here's our  
16 milestones:

17 Issue the TBM RFP, start site prep. November 30th  
18 is our date. That's the date we've been planning on for  
19 about two years. We're going to make it, it looks like.  
20 We're going to receive TBM proposals, award a TBM contract,  
21 and deliver TBM. That's one line.

22 But here is our sequence for doing the work at the  
23 portal; prepare for access and drainage, construct the north  
24 portal and a slot. We're going to start with a slot. We're  
25 going to then construct rock storage and pads simultaneously

1 with that, in parallel, construct the first 50 feet of  
2 starter tunnel, cut and cover the tunnel entry, and then do  
3 the 200 feet of starter tunnel.

4           I caution you it is preliminary. I have not given  
5 this to John, other than the November 30th date as a  
6 milestone, an absolute milestone. We're still working out  
7 the details. We don't know if we can make it. It involves  
8 around-the-clock operation out here in this area, three  
9 shifts, but I think that's the efficient way to operate  
10 anyway. So by the time we get this done, we should have a  
11 TBM on the way.

12           Someone may wonder, well, why will you finish this  
13 200 feet and not be there? Some of the scientists and  
14 engineers say we may have to drill and blast more than 200  
15 feet, it may be advantageous in the first part of the  
16 excavation because of the hardness of the rock. We won't  
17 know.

18           I hope when you come out a year from now, that's  
19 what you'll see; 200 feet into the mountain right here, a  
20 very austere drill pad. This is the only thing we're going  
21 to have here is probably some trailers and this is a  
22 temporary power area; very austere so we can get started.  
23 That's our goal, is to get started.

24           To put it in perspective, of course, put it on this  
25 map of our north ramp, we're right up here, and we'll be in

1 about this far. That's the start of the ramp. Eventually,  
2 depending how fast the TBM's move--and that depends upon the  
3 power of them, and we don't know if we're going to get a new  
4 one or a used, modified one, that's what we'll go out to look  
5 at--whether you move 50 feet, 100 feet a day, that's about  
6 6,000 feet of ramp, so you can come to your own calculations  
7 as to how long it will take us to get to the bottom. That  
8 will provide a great opportunity for the scientists to look  
9 at the faults and to examine the strata in the area.

10           That's what we're talking about, for those of you  
11 who aren't aware of what the TBM's are, about that size.

12           Here's a plan view. Being a civil engineer, I have  
13 to throw some of these kind of things in. Here is the pad.  
14 That's the little electrical building you saw. Here's our  
15 slot for starting it. Many of you have been to Exile Hill  
16 before. Trench 14 is right here. Jerry Szymanski's theory  
17 is represented in that trench, so you know where this is.  
18 This is Midway Valley. We'll have, of course, some--this is  
19 the existing road. We'll have access roads in here. We'll  
20 have a water line, water tank storage, and we'll start our  
21 muck pile.

22           Now, believe it or not in this desert, we're going  
23 to have to put a membrane under that muck pile, and that  
24 membrane's going to cost us \$2 million. That's the EPA  
25 requirements. That's the way you've got to do business,

1 because we can't prove, and we're not going to sample every  
2 piece of rock we get out of here, that we won't have  
3 contaminants in that rock; oil, whatever. So that's how we  
4 view the regulations, and how most people do.

5           I'll pass it on that I was over at Sellafield in  
6 Europe, and on their drill pad, they had to put a membrane  
7 under their entire drill pad. So it's not just United States  
8 regulations, it's the environmental regulations that many  
9 countries in this world are going to. So it's not unique to  
10 our environmental activities.

11           Here's some more engineering drawings. This is a  
12 section of the entry into Exile Hill, the first part being a  
13 concrete portal face and a multi-plate steel arch, and then  
14 we'd start our starter tunnel in here. That's just to show  
15 you what it looks like in section, and this design is still  
16 being finalized. As some of you who did participate in the  
17 design review, this is in plan, of course, and this is the  
18 steel arch over the top, and that's the slot and then we  
19 start in. Then, of course, there's our first test alcove.  
20 So we start testing not only mapping as we go in, but we'll  
21 start testing as soon as we get in there.

22           That's ESF. That's our focus next year. I'm not  
23 going to go into as much detail on some of these other  
24 things, but let's talk about what other things are we going  
25 to do, because when we say ESF, many other elements of the

1 work breakdown structure support ESF.

2           Certainly, we're going to do UZ-16 and complete  
3 that. We're not going to work around the clock right now, to  
4 the best of my knowledge--although that's the most efficient  
5 way to use a big drill rig, but we don't have money to do  
6 that. We are going to complete these boreholes along the  
7 ramp alignment so we can design the rest of the ramp and  
8 start at the south ramp and do a borehole there. It provides  
9 design data for the engineers. Although it's in this budget,  
10 it's really ESF work, too. It just happens to be the way we  
11 account.

12           We are going to complete our drilling and data  
13 collection in support of Alan Flint's unsaturated  
14 infiltration studies. There's only seven more holes to go  
15 there. We need to revise any study plans and job packages  
16 for the tests in the ESF. When we get in there, we want to  
17 be able to do the tests. The only reason we're building it  
18 is to do the tests, so we have to do that. We have to  
19 complete the trenching program in Midway Valley, and most of  
20 the trenching program for Quaternary faults. John has given  
21 me a priority to try to close the seismic issue a little bit,  
22 so we're going to be focusing on seismic activities.

23           We going to continue the collection of data that  
24 would otherwise be lost. I think you're aware, the seismic  
25 network, as of the first of the year now, is being run by the

1 University of Nevada, Jim Brune. In fact, he's speaking next  
2 week at the ACNW activity. He's running that for us. We're  
3 going to do some pump tests in a C-well complex, and when we  
4 finish UZ-16, we'll be moving on to UZ-14.

5           Now, for 50 million, that's just a few bullets.  
6 There's a lot more, and we can go on and on. In fact, Russ  
7 Dyer gave me a package that thick when we went over it in our  
8 budget presentations, but I'm just highlighting some of the  
9 things for you.

10           In 1.2.5--you notice I didn't go numerically, 1, 2,  
11 3. I went to kind of what I think is some of the important  
12 things first; ESF, site, and now the regulatory activity, 23  
13 million. In this category, we have, of course, monthly  
14 interactions. We have to prepare and issue documents. We're  
15 committed to provide comment responses to the early site  
16 suitability. We have been working on the 191 reviews. I  
17 don't know if we'll be doing some more work with the National  
18 Academy on the new approach. Who knows if we'll support them  
19 or not? If they ask, we will.

20           Two semi-annual progress reports for the site  
21 characterization program, that's a legislative requirement.  
22 That's required by law. We're probably going to do one  
23 revision to the annotated outline next year, and we'd like to  
24 close some issues. One is erosion, the other is seismic  
25 hazard, and work on volcanism--which isn't in here--too.

1           We're also going to revise our regulatory  
2 compliance plan. We now, at Yucca Mountain, have clear  
3 responsibility for three things. As the Associate Director  
4 for Geologic Disposal, I'm responsible for the license  
5 application, for the EIS that goes with that, and for the  
6 site suitability determination. John has provided me that  
7 direction. I'm developing some strategies with my staff for  
8 that. But now, if someone asks, "Who's responsible for the  
9 license application in OCRWM?", only one guy's going to raise  
10 his hand, and that's going to be my organization. Other  
11 people will review, provide regulatory oversight, but it's  
12 clearly our responsibility.

13           We have to add these initiatives to that plan, and  
14 we're going to revise some study plans, as needed. Why do we  
15 have study plans in both categories, you ask? The writing of  
16 the study plan is done by the scientists under 1.2.3; the  
17 review and regulatory pushing forward of them is done under  
18 1.2.5. That's the way we account for it.

19           We have a lot of technical data to manage;  
20 parameter dictionaries, revise our technical data book. If  
21 you don't have our technical dictionaries, let us know. We  
22 put out our data report. We'd be glad to share them with  
23 you, but that's a big package in itself. That includes the  
24 GIS, geographic information system, and performance  
25 assessment happens to fall in this category; I think,

1 appropriately so. It's a regulatory base requirement, but it  
2 also helps us set priorities.

3           We will prepare for our second total systems  
4 performance. We'll use it for thermal loading analysis,  
5 support surface-based testing, next generation EBS model, and  
6 whatever study plans are needed to support site  
7 characterization activity, whatever PA is needed for them.

8           Now we move on to 1.2.1, systems, about \$6 million.  
9 We need requirements documents for traceability so we know  
10 we're meeting regulatory requirements and other environmental  
11 requirements, as well as project management requirements.  
12 This, in essence, continues our document hierarchy work, it  
13 develops and issues some mined geologic disposal system  
14 documents. It is our change board activity.

15           We have set documents. We've been doing a lot of  
16 work. Win Wilson, out at the site, has, I think, the last  
17 count was he had 57 change board actions. Even for the  
18 limited amount of work we do. We can change. It's not a  
19 problem. You just have to document it, that's all.

20           This also conducts conformance reviews that are  
21 designed, will meet the new requirements. I think you  
22 remember an initiative that was established by John when he  
23 first came in, called "Management Systems Improvement  
24 Strategy." That has developed a new suite of documents,  
25 performance-oriented documents, and we're working on an old

1 suite. We don't think there's any holes in it, but we're  
2 going to have to make that conformation. We're pretty sure  
3 there isn't, but we're going to have to make that cross-  
4 check.

5           Develop specialty engineering plan, value  
6 engineering cost savings activities go on here, special  
7 studies, tradeoff analyses between ESF, repository engineered  
8 barriers, design activities, what helps, what hurts, and we  
9 support what we call a total system life cycle cost analysis.

10           Waste package. You know, we all talked the last  
11 day and a half about this category. Well, there's 8.3  
12 million in the category for next year, but I asked Dave Stahl  
13 to summarize all this activity that went on in the last day  
14 and a half. What was the cost of that, and what would be the  
15 cost next year; about one and a half to two million dollars,  
16 in a quick thing. So what you saw was only a very small part  
17 of this activity. It was this, and probably that is what you  
18 mostly saw.

19           But next year, what are we going to do for 8.3?  
20 Well, we're going to start our advanced conceptual design, do  
21 some calculations, develop concepts, conduct some thermal  
22 loading options, start some large block tests. I'm convinced  
23 at this time that that's important. We're not going to have  
24 enough money to go into Busted Butte with a testing facility,  
25 but the scientists tell me we can get some information from

1 these large block tests.

2           We'll develop some plans for testing in the ESF,  
3 because we're going to get down there maybe a little sooner  
4 now with one TBM. We continue long-term testing of spent  
5 fuel, survey and testing of metal barriers, and continue the  
6 release modeling, of course, and that was going on the last  
7 two days, too, so that's kind of the modeling that was going  
8 on.

9           Repository. We have an element called repository.  
10 We're not building a repository, but the ESF has to be  
11 integrated, by regulation, into the repository. Some of the  
12 analysis for the ESF, because a repository will be hot, we  
13 have to make sure our openings at the ESF are compatible to  
14 repository design, so some of that analysis is being done in  
15 this category.

16           We are going to start our advanced conceptual  
17 design. We need to get that started. We'll do our basis for  
18 design documents. We'll continue some laboratory and rock  
19 mechanics tests, complete our drawings of a proposed  
20 repository, because in order to show that an ESF is  
21 compatible with a repository, you have to have some  
22 repository drawings, some repository design.

23           We'll talk about waste emplacement equipment, just  
24 so we can do appropriate tradeoff studies. People are  
25 continually interested in our borehole sealing requirements.

1 It happens to come under here, and we'll investigate grouts  
2 for borehole sealing.

3           Test facilities. This is kind of a misnomer, but  
4 it's really facilities that support tests. Win Wilson  
5 supports the people out in the field, be it with bulldozers  
6 or drills or whatever. We also have a lot of tours and  
7 outreach activity out there now. We're going to develop a  
8 conceptual design for the area. As we start to increase our  
9 activities, we need warehouses, we need all different things  
10 for build-up. We need fire protection in our own site  
11 office. We don't have appropriate fire protection to the  
12 codes out there now. We have a waiver, because it's not a  
13 personal hazard, but it is a property hazard.

14           Construct hazardous materials storage area, as part  
15 of RCRA, we're now going to be using oils and grease and  
16 everything. We have to document exactly how we use them and  
17 what we do with them, not due to NRC, this is due to RCRA-  
18 type things, and we begin an area complex near J13, where  
19 we're probably going to have some more office buildings for  
20 the people close to do their work, for medical facilities,  
21 what we need.

22           And in order to supply that, we're taking some  
23 facilities from Tonopah. That's the Area 51, the Stealth  
24 bomber. That's been shut down. They have some great mobile  
25 offices, some great mobile facilities; only been up there a

1 relatively short time, and we're bringing those down and  
2 we'll put them in place probably at this complex when the  
3 time comes.

4           Program management is this category. It includes  
5 several things; writing procedures, not change board impact,  
6 but change board procedures are done here, compliance reviews  
7 for procurement. The PACS system is run out of this,  
8 software so our division directors--they now get a printout  
9 on paper monthly to tell how their activities are doing. We  
10 want to work software so they can come right up on their  
11 computer to see how they're doing, so that can do it even  
12 without paper.

13           Financial assistance. This is money directed to  
14 the State of Nevada for oversight, to the affected counties,  
15 cooperative agreements with universities, and payments equal  
16 to taxes. A little bit of debate, this may be 4.2 instead of  
17 3.7, depending how you read the law and, John, you're shaking  
18 your head. The new reading is whatever--4.6, or whatever it  
19 is. Now I've lost 600,000 already out of the rest of my  
20 project amount. And payments equal to taxes, our estimate of  
21 what that might be.

22           Just so you understand how some of the systems  
23 work, I think Nye County's first estimate for taxes was in  
24 over the 100 million range, so we're a little away from  
25 reaching an equitable payment for taxes with Nye County.

1           Quality assurance program. As I said, I can't be  
2 more pleased. I'm just really pleased with Don Horton and  
3 his approach to quality assurance and how he's worked,  
4 providing a sound quality assurance program. Certainly, we  
5 want to support ESF. We think we're trying to streamline the  
6 program all the time. People like Larry Hayes and some of  
7 the scientists worked on what we call a QIG, quality  
8 integration group, and they really were able to get together  
9 a meeting of the minds, and I think that's helped the program  
10 immensely.

11           I've asked Larry to pick up another duty along  
12 those lines, since he did so well in that. We're looking at,  
13 do we have to look at all these requirements that are out  
14 there, all the environmental requirements, because Larry  
15 says, "I need money for drilling, and why do we have to do  
16 this and this and this?" So I've asked him to head up a task  
17 force to look at that, to make sure we're doing only what's  
18 necessary, and not what everybody would like to do, and in  
19 that way, he may understand what is necessary, too, because  
20 the people out there are saying, "Why do we have to do it?"  
21 Well, some of that comes with understanding.

22           QA, I think, is running very well right now.  
23 Information management, we're developing a lot of data.  
24 We're, under Barbara Cerney's headquarter's guidance, we're  
25 implementing lots of things out here in the field, document

1 control, record center, software development, operate the  
2 computer center, operate our VAX cluster, start what we call  
3 InfoSTREAMS. That's the implementation that eventually might  
4 lead to the licensing support system, and support other  
5 record management activities; record inventory and  
6 disposition schedule. We're trying to figure out what  
7 records do we need to keep and which ones don't we.

8           Environment, safety and health, Wendy Dixon's  
9 program, it's a comprehensive program all required by law.  
10 Before we drill anything, we go out and do a pre-activity  
11 survey, make sure we don't have any archeological problems,  
12 any environmental problems. That's all part of the activity.

13           Continue our monitoring. We monitor for air,  
14 meteorological monitoring, water resources, terrestrial.  
15 You'll hear Wendy talk about some of her program tomorrow; do  
16 the permitting activities. I just showed major permits.  
17 We're continually getting small permits. It's just part of  
18 doing business within the state; actually, out of the state,  
19 too, for work we do in California.

20           Continue environmental audits and surveillance,  
21 implement this. This is expensive; hazardous materials  
22 control.

23           We've got some new programs. We have a DOE  
24 Radiation Control Manual. Right now I'm told that's going to  
25 cost me a million dollars a year to implement this manual.

1 The Secretary has not given any exceptions to that. That  
2 requires training for everybody. Why? We don't have any  
3 radiation. Well, we're on the Nevada test site where there  
4 were test programs on the nuclear rocket before, where there  
5 is possibly--some fallout, so our orders, we're going to have  
6 to get trained and implement a new program here.

7           We have been working with the Native Americans, 16  
8 tribes. We do socioeconomic and regional studies as part of  
9 the site suitability requirements and, eventually, NEPA;  
10 continue compliance with health and safety, maintain our  
11 health and safety and establish protocols for functional  
12 appraisals as part of the Secretary's self-assessment  
13 initiatives.

14           Institutional. Not much, \$3.5 million, but that  
15 supports interactions with the State of Nevada, public  
16 interest groups, business community, operation of the three  
17 info offices, speakers, bureaus, tours, exhibits, educational  
18 programs--we're getting lots of requests from the schools  
19 right now--Yucca Mountain media relations, and various  
20 publications. There's some new publications out there right  
21 now you're welcome to.

22           Planned accomplishments for support services, this  
23 just shows you where this money goes. It's rent, it's motor  
24 pool, it's telecommunications, it's graphics, it's clerical  
25 support, and then, in that category, also includes training.

1 We do an extensive amount of training required by several  
2 regulations.

3           Before I go on to challenges, I want to point out,  
4 what does this mean? What does this mean to Nevada, the new  
5 budget? It means we're probably going to have 200 more  
6 people working out at the ESF area, 200 construction jobs.  
7 People will be out there working, 200 more than are out there  
8 drilling now, and trenching, so that's what it means.

9           Let me just briefly go over the challenges and  
10 issues. The first one John alluded to: modify the program  
11 as appropriate to be consistent with the new energy  
12 legislation. We're going to have to do that. We're not  
13 going to do that quite this year because we don't know what  
14 that's going to be, but we're going to have to think about  
15 that as we do it. We do have adamant state opposition,  
16 intense media attention. That's just the way of doing  
17 business on this project. It is fairly unpopular in the  
18 state. People want to know what's going on.

19           Complex science and the 10,000-year question, maybe  
20 some of that might be addressed by the new legislation, but  
21 the people have a hard time understanding 10,000-year  
22 questions.

23           Adequate funding. Right now, simply, we are  
24 funding limited, although we have, on the project 60 more  
25 million dollars this year to spend, and John did point out,

1 we got 100 million from the Congress, but John last year  
2 provided me 20 million--30 million, I guess it was--from  
3 carryover, so, really, I spent 180 million last year. I'm  
4 going to spend 245 this year. Without the 100 million, my  
5 budget was 150 million, so we were looking at bad times until  
6 Congress came through with the extra 100 million. We hope we  
7 can get out of this constant hassle on funding by some kind  
8 of revolving account.

9           I just keep this up there as a reminder. We've  
10 overcome the QA record keeping and procedures. I think there  
11 will also be outliers, people who don't quite like it, but  
12 we've really overcome that. We've overcome this, I think,  
13 now, too. We move from planning to execution. TRW is on  
14 board, the M&O team's full bore doing the integration and the  
15 major contribution activities that have transitioned to them.

16           We are going to look at issue resolution. We're  
17 going to try to focus the program. You know, it's not only  
18 enough to work hard, which I think everybody in the project's  
19 doing, but are we working hard on the right things? And this  
20 is the convergent activity that tries to determine, are we  
21 working hard on the rights things, and are we going to  
22 converge and get a site suitability determination, and  
23 eventually, the site recommendation, license application,  
24 environmental impact statement, all in accordance with the  
25 broad suite of laws, using site characterization data and

1 performance assessment to iterate the information for not  
2 only regulatory compliance, but design, and redirection of  
3 the site characterization program, or establishing additional  
4 needs. So it's an iterative process. That's what it's all  
5 about. We're trying to describe that now in what we call a  
6 convergence plan.

7           My last slide, I think. We still need help to  
8 continue moving on; litigation or legislation to assure  
9 permits. Litigation has been successful, but I keep it up  
10 there as a reminder, should the state change their position  
11 at any time. We need departmental and Congressional support  
12 for funding. Permits without funding is not enough. Funding  
13 without permits won't get us there, and we have to assure  
14 regulatory compliance is reasonable, with a cost effective  
15 basis in accordance with the new Energy Bill.

16           That's some of the things that we're going to need  
17 help doing. Without all of the above, this program could  
18 become stalled. If this program becomes stalled, we won't be  
19 addressing environmental issues, what to do with the 65  
20 locations where there's hazardous spent fuel, and as part of  
21 the national energy strategy, many people believe progress  
22 towards waste disposal will keep the nuclear option open.

23           With that, I'll take any questions you might have  
24 for as long as you like.

25           DR. CANTLON: Questions from the Board?

1           Let me start off with an easy one, Carl. Where you  
2 were looking at the Congressional examination of your budget  
3 early on, you talked about the scientific test work, and your  
4 slide said "have been prioritized," and I notice you changed  
5 the language orally to say, "are being."

6

7           MR. GERTZ: I guess Jean maybe talked a little bit when  
8 I was out of the room earlier, but we have an integrated test  
9 prioritization activity going on. Some are being  
10 prioritized. We know UZ-14 is the next hole that most of the  
11 scientists want to get at. They think that's a priority,  
12 so...

13          DR. CANTLON: Could you give us a kind of a ball park  
14 guess at where you think you are on that; half-through,  
15 quarter-through, two-thirds?

16          MR. GERTZ: Jean's been working that. I'll let Jean  
17 answer that. I'm interested in the answer myself, too.

18          DR. YOUNKER: This is Jean Younker from the M&O.

19                 We've provided a draft report to Russ Dyer, Carl's  
20 Division Director, who's responsible for getting the  
21 priorities sorted out in the testing program, and he used our  
22 draft input as the basis for trying to put this together, put  
23 the FY93 funding together, working with the managers from  
24 USGS and the national labs, so it's already being used. The  
25 final report has not yet been provided, but...

1 MR. GERTZ: But the fact is that the data's being used,  
2 and that's what Russ presented to me in his budget  
3 presentation.

4 DR. CANTLON: I take it from that, since the figure was  
5 prepared from that, you're suggesting that the work has been  
6 done?

7 DR. YOUNKER: Yeah, this is Jean Younker again.

8 To the extent that they could, I think, given the  
9 kinds of constraints that DOE has to use whenever they make  
10 budgetary allocations, I think they've used it to the best of  
11 their ability this year to try to put the test priorities in  
12 place that we recommended.

13 MR. GERTZ: We do have a document out. In fact, John  
14 was given a presentation by video conference, in an effort to  
15 save money on the integrated test prioritization activity.

16 DR. CANTLON: Other questions from the Board?

17 DR. DOMENICO: Domenico.

18 You said UZ-16, is that one of your priorities that  
19 you--

20 MR. GERTZ: That's the one we're drilling on right now.  
21 We're 800 feet deep on it. We're going to go to 1600 feet  
22 deep with that, then we go to UZ-14.

23 DR. DOMENICO: I see. I noticed the handout on it. You  
24 started in May.

25 MR. GERTZ: That's correct.

1 DR. DOMENICO: My calculation says you're getting seven  
2 feet a day. Are you having trouble with that rig?

3 MR. GERTZ: We're not having as much trouble with the  
4 rig, in that what we're having trouble with, we're not doing  
5 three shifts. We probably should be working 24 hours on it.

6 DR. DOMENICO: You're not doing three?

7 MR. GERTZ: No, sir.

8 DR. DOMENICO: How many days?

9 MR. GERTZ: One shift, five days a week is all we're  
10 doing, and you know the time it takes to get ready, and the  
11 time to shut down. We did have a transmission that went out  
12 that we had to repair on the drill rig, and we lost some  
13 other activity there.

14 DR. DOMENICO: It's still low. It's still less than ten  
15 feet a day.

16 MR. GERTZ: You can talk to Uel tomorrow. When it's  
17 working right and everything, we're getting, I think, 20 to  
18 30 feet a day on one shift.

19 DR. DOMENICO: Will we see it tomorrow?

20 MR. GERTZ: Yeah, you'll see it tomorrow and you can  
21 talk to the people that are doing the work tomorrow. They'll  
22 be out there. That concerns me, too. I'd like to be doing  
23 more.

24 DR. CORDING: Carl, last year, I think the plan was to  
25 add more LM-300's, but at present, you're going to stay just

1 with the one; is that correct?

2 MR. GERTZ: Yeah, that's correct. We had a budget  
3 amendment in that didn't get in for an extra 75 million.  
4 That would have ordered two more LM-300's. It would have  
5 provided for around-the-clock operation which, as a project  
6 manager, I think is the most cost-effective way to do it, but  
7 that didn't get in and we think that now it's time to--we've  
8 listened to you--it's time to get underground with the ESF,  
9 and that's what we're really focusing on, and just continuing  
10 the ongoing program, but not expanding it.

11 DR. CORDING: And using that on a one shift per day--

12 MR. GERTZ: One shift per day, that's what our budget  
13 is.

14 DR. CORDING: --operation at present for the LM-300?

15 MR. GERTZ: That's correct. I'd like to do it more. As  
16 I said--

17 DR. CORDING: Are you looking into the possibility,  
18 then, of changing the scope of the dry drilling program to  
19 perhaps do more sampling; take samples, for example, of  
20 zones, rather than all the way through?

21 MR. GERTZ: Yeah. Larry Hayes is eager to jump up right  
22 now, but, yes. In my effort to try to reduce costs, I've  
23 asked the TPO's to look at things like that. Do we need full  
24 core from every one of the holes, or can we get intermittent  
25 core? It would save us a lot of time, and Larry's provided

1 some thoughts on that. Larry, if you want to even mention it  
2 right now, it'd be fine.

3 MR. HAYES: Larry Hayes, USGS.

4 Yeah, we're all worried about what we're seeing as  
5 very low drilling rates. I think we're all coming to the  
6 realization, with funding limitations to get additional rigs,  
7 with funding limitations to put on three crews, drill around  
8 the clock, we're not going to get the drilling done that has  
9 to be done with this one rig.

10 We have had some preliminary meetings, the  
11 scientists, some of the technical managers, to look at what  
12 we can do in our drilling program to get the information we  
13 need most in a timely manner. We're looking, at this point  
14 in time, of dropping some holes, reducing the amount of core  
15 we would take. For example, we may core a few index wells,  
16 then we'll run geophysical logs on those index wells, and  
17 then we'll core other wells only in selected areas.

18 One of the big delays in drilling is the dry  
19 drilling. We're also looking at, where appropriate, where we  
20 can, we're going to go back to conventional drilling methods.  
21 We've got a meeting here at the end of this month to  
22 finalize these plans, and I think what we're going to end up  
23 doing is reducing considerably some of the drilling  
24 requirements, not only holes, but how we're doing it, so we  
25 can move ahead more quickly with less money, and you'll hear

1 more about that tomorrow from Uel Clanton and myself.

2 DR. CORDING: Some of that, Larry, you're talking also  
3 about what--I assume some of that will be going to the  
4 underground program in terms of the type of sampling or  
5 testing that's being done, that could have been done in dry  
6 drilling, that can now be transferred to the underground; is  
7 that also a part of your effort?

8 MR. HAYES: That's correct. That's a very good point.  
9 What we're looking at is, okay, what are we going to learn  
10 underground that we can now minimize or eliminate some  
11 surface-based drilling requirements.

12 MR. GERTZ: Ed, you're alluding to a very good point,  
13 and I'll make it if you don't, is our drilling program was  
14 predicated on an ESF that only had 6,000 feet of exploration,  
15 or something like that. Now we have 14 miles of exploration.

16 DR. CORDING: Of underground.

17 MR. GERTZ: Can we change--underground exploration. Can  
18 we change the drilling program? Are we going to get some  
19 data from that?

20 DR. CORDING: Yeah. I think there's very many  
21 opportunities that will be present underground, and I think  
22 that's a very valuable and very important thing to consider.

23 MR. HAYES: Yeah. We're working on that with the Los  
24 Alamos people, who are the underground coordinators, and we  
25 think we see some really good tradeoffs there.

1 DR. CANTLON: Other questions from the Board?

2 DR. LANGMUIR: Carl; Langmuir.

3 Looking at your budget details table, perhaps you  
4 can remember the figures. In essence, I wanted to know, does  
5 site mean the surface-based testing?

6 MR. GERTZ: Essentially, yeah. If you look under the  
7 work breakdown structure, site's geology, hydrology, it also  
8 means the laboratory testing and geochemistry. Los Alamos  
9 work is under site.

10 DR. LANGMUIR: Okay. So basically, that's the surface-  
11 based testing aspect of things and its support?

12 MR. GERTZ: Yeah. It includes the drilling, too; the  
13 work breakdown structure. This would be the one--we go down  
14 to much other levels, but in site, we have coordination and  
15 planning, geology, hydrology, geochemistry, drilling,  
16 climatology, resource potential, deferred site close-out, and  
17 special studies. So that's those programs.

18 DR. CANTLON: Other questions from the Board?

19 (No audible response.)

20 DR. CANTLON: I have one, Carl. On the 1.2.4, the  
21 repository item, you had a four and a half million dollar  
22 there, and one of the sub-items was "initiation of conceptual  
23 drawings for waste emplacement equipment." What's the waste  
24 emplacement configuration you're thinking about? Are you  
25 still looking at vertical boreholes?

1 MR. GERTZ: Right now, the reference case is vertical  
2 borehole, but if we're going to develop indrift emplacement,  
3 we need to figure out what kind of equipment we might need to  
4 make that retrievable for 50 years, and how would that affect  
5 the size of the drifts, and do we assure that we don't  
6 oversize or undersize our ESF and make it compatible with  
7 future repository designs.

8 DR. CANTLON: So the conceptual design is looking at the  
9 alternative emplacement?

10 MR. GERTZ: That's correct. We have pretty good designs  
11 already in our current conceptual designs if you've seen that  
12 for the equipment, for borehole emplacement, but that is six  
13 years old.

14 DR. CORDING: Carl, could you give a little--just  
15 briefly, a breakdown on some of the--where the 49 million is  
16 going on the exploratory studies facility?

17 MR. GERTZ: Sure. Maybe.

18 DR. CORDING: Section 1.2.6.

19 MR. GERTZ: Now, is Ted here? Who's here to help me;  
20 anybody? Bill's here. Bill, do you recall?

21 We'll get you a detailed one, because we have the  
22 cost estimates, but maybe I can--I'm really speaking off the  
23 top of my head now, but I think site prep and construction  
24 and everything is in the \$15-18 million category in the first  
25 bullet, but we'll get you the details so I'll just give you a

1 thought process for talking now.

2           I think this is somewhere in the \$5-10 million  
3 range. If we're going to award this contract, I think I have  
4 to set aside about \$10 million here to make a proper award.

5       DR. CORDING: And that's the contract for the machine,  
6 for the TBM?

7       MR. GERTZ: This is for the TBM itself.

8       DR. CORDING: And not the contractor, but the TBM?

9       MR. GERTZ: Not the contractor. That's for the  
10 contractor. I don't have to set much aside for that, because  
11 that's labor--I mean, that's consulting-type work right now.  
12 This is for the machine. This, also, is in the \$5 million  
13 range, off the top of my head, and that's some of the big--

14       DR. CORDING: Is that a permanent power supply, or is  
15 that generators?

16       MR. GERTZ: It's not generators. It's upgrading the  
17 current NTS so that we can use it for at least the first TBM.  
18 Our concept now, of course, is one TBM. When we get to  
19 Calico Hills, we'll decide if we're going to use another one  
20 at that time or not, and maybe it'll be one--as you all  
21 suggested some time ago--one that goes down and makes the U,  
22 comes all the way around and comes out, and that may be our  
23 very first shot, depending on funding. We'd like to buy one  
24 in '94 to do the Calico Hills, but we'll get you that detail,  
25 and we have those details. It was given to me in

1 excruciating detail.

2 DR. CANTLON: Other questions?

3 DR. LANGMUIR: Carl, realistically, looking at your  
4 budget, you show, in effect, a jump of 100 million each in  
5 surface-based testing and exploratory studies facilities  
6 budgets, more than you have this year, more than the 100  
7 million you just got. I wonder what you plan to do if you  
8 don't get it. What's going to happen? What are the  
9 contingencies?

10 MR. GERTZ: If you don't get it, we'll probably continue  
11 a one-TBM approach and extend the schedule. I mean, if  
12 you've got a limited scope of work, you either need the funds  
13 to do it in that time, or extend the time.

14 DR. LANGMUIR: Are we at the end of saying that we're  
15 going to make it by the deadlines?

16 MR. GERTZ: I am at the end of saying I'm going to make  
17 it right now. I think I can still say I'm going to make it  
18 with the funding that's provided to me in '93, a little  
19 riskier than I could say a year ago. I'd rather have 318  
20 million than 244, but I still think we can make it based on  
21 the Mission 2001 study in our talk.

22 But if we don't come up with the funds in the out  
23 years, maybe we can't even spend all that money in the  
24 Mission 2001. Maybe we can't spend all that in the out  
25 years, but we'll have a commitment and it'll be there, and

1 the momentum will carry on. There is some question of  
2 whether we can spend that. Well, you can buy equipment, you  
3 can buy two or three TBM's, you can work around the clock in  
4 many areas, and you can spend money pretty quick because we  
5 have that foundation in place that we use in our foundation  
6 chart.

7 DR. CANTLON: Okay. Perhaps we can take one more  
8 question. Any questions from the staff?

9 (No audible response.)

10 DR. CANTLON: Any from the audience?

11 MR. GERTZ: Don, I just wanted to make sure we were on  
12 the right track, and you were talking about the expansion in  
13 numbers from here to here in ESF and from here to here in  
14 site; is that right?

15 DR. LANGMUIR: Yes.

16 MR. GERTZ: Okay, and here's the expansion we're looking  
17 at. We don't have 321, we have 244. Probably I'll have to  
18 spread some of that out. It might not be 685--now I'm just  
19 talking off the top of my head as the project manager--but  
20 it's in the 600-range that we're going to need to keep on  
21 this schedule. If you don't get it, things just go to the  
22 right, because we've pushed the critical path. Almost  
23 everything's on the critical path. Now surface-based testing  
24 is, now ESF testing is, now design of the waste package and  
25 repository is, performance assessment, calculations, getting

1 the data to them in time. We've really pushed everything  
2 onto a critical path, almost. That's kind of a non sequitur,  
3 but...

4 DR. CANTLON: All right. We'll take one more question.  
5 Ed?

6 DR. CORDING: Just one question, Carl. You had  
7 indicated there that you're looking through costs for the  
8 remaining, something on the order of \$3.6 billion program,  
9 and the test programs, and you were also indicating, I  
10 believe, that you were looking at costs of management; is  
11 that correct?

12 MR. GERTZ: Oh, yes.

13 DR. CORDING: All the way up and down through the  
14 system?

15 MR. GERTZ: Up and down through the whole thing, and  
16 that's one of Larry's task force that I'm setting up for,  
17 because he's saying, "Gee whiz, it costs us a lot to drill  
18 these days," and he's right, it does cost a lot to drill  
19 because he has to have an archeological survey before he  
20 starts, an environmental survey. We have to take care of the  
21 grease and the oil and document where we're going with that  
22 and who's bringing it on site, and where we're going to store  
23 it when we're finished with it, and all that adds to the cost  
24 of doing business.

25 As I said, it's not unique to this country. It's

1 not unique to this program. The oil people I've been talking  
2 to, they just put out a report saying they have to shut down  
3 about half their exploratory wells because of the cost of  
4 doing business and the current environmental regulations.  
5 But we're going to look at them. Just because they're there,  
6 John makes the good point, we don't want to overkill the  
7 requirements. There's a requirement, but do you have to do  
8 twice that requirement, or just the requirement? And  
9 certainly, there's a tendency of some people who want to be  
10 just a little safer or a little surer. But we want to be  
11 safe. We want to do all the requirement says, but we don't  
12 want to do more because then we're taking away from other  
13 things.

14 DR. CANTLON: Fine. Thank you, Carl.

15 Well, this brings our day and a half session to a  
16 close, and on behalf of the Board, I'd like to thank all of  
17 the speakers who presented papers, our consultants who have  
18 come in, the audience, who have participated in many helpful  
19 ways on a number of these suggestions, and so, with that,  
20 declare this session of the Board adjourned.

21 Thank you very much.

22 (Whereupon, at 4:05 p.m., the meeting was  
23 adjourned.)

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