
PRESENTATION TO

THE NUCLEAR WASTE TECHNICAL REVIEW BOARD

St. Tropez

455 E. Harmon

Las Vegas, Nevada

June 27, 1989

8:30 A.M.

A L S O   P R E S E N T :

CHAIRMAN DEERE
DR. BLANCHARD
DR. BARNARD
DR. MC FARLAND
DR. CARTER
DR. CORDING
DR. ALLEN
DR. WILLIAMS
DR. DOMENICO
DR. ISAACS
DR. SALTZMAN
DR. GERTZ
DR. NORTH
DR. COONS
DR. PRICE
DR. CANTLON
DR. VERINK
DR. LANGMUIR

CHAIRMAN DEERE: Good morning. This is the second day of the meeting of the Nuclear Waste Technical Review Board.

I am Don Deere, Chairman, and I would like to welcome you to the second day's meeting.

I would like to announce that those going on the Yucca Mountain trip tomorrow who wish lunch should place orders at the table at the lobby by noon today. Those in attendance who have not signed in as attending the meeting, please do so during your first break.

Also we would like to continue with the format that we had yesterday. This is primarily a meeting for the Technical Review Board to receive information today from the Department of Energy.

Those in the audience are asked not to raise questions. These will be raised, as desired, by the various members of the Board.

Now, I would like to turn the meeting over to the Department of Energy to Mr. Carl Gertz.

DR. GERTZ: Thank you, Don. I appreciate the opportunity to address the Board. We certainly want to welcome you on behalf of Nevada and on behalf of the Yucca Mountain Project.

We're here to meet your needs today. Certainly throughout my presentation and the presentation over the next couple of days, please feel free to ask us questions, whatever it takes, to meet your needs to provide you with the information that you feel is necessary. That's our goal.

I am Carl Gertz. I'm Project Manager for the Yucca Mountain Project. I live here in Las Vegas and I've been with the project for two years.

Before I get into the presentation, let me address how the Department of Energy does business.

Energy Secretary James Watkins' philosophy is to be kept apprised of certain activities. To accomplish this, one must be close-at-hand, which means residing in Washington, D. C., such as Sam Rousso in this particular office. Out in the field we implement that policy and direction. We implement through field offices and project offices that are part of this.

Nick Aquilina is on two programs, the Underground Testing Program, and the Yucca Mountain Program.

With that I want to expand a little bit on the Yucca Mountain Project. These are the 1,400 people signed on as engineer's who are accomplishing the scientific and technical background for Yucca Mountain.

Across the bottom line is where the bulk of the scientific work is being done. At three National Laboratories and the United States Geological Survey, naturally emphasis is on the study of hydrology and climatology.

Sandia National Laboratory is our laboratory that's addressing performance assessments. Also the initial design.

Lawrence Livermore National Laboratory has done designs and is responsible for the environment with interest between the waste package design, the water, and the rock.

Los Alamos National Laboratory is responsible for volcanism; geochemical investigations; and some of the planning for the exploratory shaft. That's where the bulk of the scientific input is being accomplished. Engineer's and construction is for the exploratory shaft, not for the repository.

We have two on site engineer's. Fenix & Scisson are handling the underground facility and Holmes & Narver are handling the above-ground facility. Reynolds Electrical & Engineering Company provides construction site support for the investigators and for the construction and for the exploratory shaft. We have signed with Science Applications International Corp. which does some of the work but is in charge with what's going on across the project. Mactec provides us with Quality Assurance Consultant Services, all of which is managed by my office, probably 80 federal people, and I have direct-line responsibilities with all these organizations either through direct contact or memoranda so there is a single manager in control in this entity.

Let me just talk about an overview of today's presentation. You're going to hear a description of the site geology and hydrology. We're going to provide you with examples of use of site data that we've used to assess volcanic and seismic hazards and then you'll hear about our plans for site characterization.

I believe there is a couple of issues I need to address right now. One of them is the issue that was raised yesterday by the State Investigator's about the provision of data.

No doubt about it, in the past our record has not been very good. We have been a little bit slow getting data out. It's due to a lot of reasons. Some of which are mechanical. Some of which are procedural. Some of which are institutional.

We have implemented just recently some procedures that provide for data to be available within 45 days so I think we're well on our way to solving that problem. I'd like to think that that's a problem of the past and when you come here again, that won't be an issue any more so we hope we're on our way there.

I'd like to address the seismic tapes. The state has made a request that we provide 429 tapes. It takes time to copy that many. They don't have them yet but they'll get them. They had over 1,000 splices. There was a couple errors in the splices but we will provide the data to the state and the NRC. It has to go through some procedural aspect of quality assurance verification but as soon as it's ready, we want to provide it. That's our overall policy.

Second issue I want to discuss is an item of interest. It happens to be in the news and it's going to be coming up in the next month. Jerry Szymanski, who I think is in the room today, has provided or is getting ready to provide a second revision to his manuscript. Certainly his theories involve some of the coupling effects including the rise in the water table. We hope to have his revised report issued near the end of July and that may very well be a subject of future discussion with you and the Board but we want to let you know that you'll be hearing about it in the future.

Now, let me talk about our goals. We intend to start some new site characterization activities in 1989.

There is one thing that we agreed with what the state said yesterday. There are many things we agree with, by the way. We need to gather more data. We want to get out in the field. I'll talk to you a little bit later about some of the things we have to do but we'd like to gather new data. We'd like to do some trenching to examine for faults. We'd like to go over Exile Hill, Trench 14, which you heard discussed yesterday. We want to do scientific investigations there. Besides several things we need state permits to get on the property and I'll talk more about that later.

Let me address the schedule a little bit right now. You saw our near term goals. You say we want to start new in 1989. We have five to seven years to spend one to two billion dollars. We don't have enough information to determine suitability or unsuitability. That's why we have to try to understand Yucca Mountain better. We'll gather data. We'll submit that to the NRC by three or four years to review it and then get on with construction.

We're setting some near term goals but right now the Secretary of Energy has indicated that other dates are subject to review by his management team so these dates, although they're currently published, are subject to review by the Secretary of Energy. We're doing a bottoms-up which will be coordinated with management approval.

Six thousand activities we're putting durations on them to assure we're getting all the data necessary to determine Yucca Mountain suitability. If Yucca Mountain is not suitable, if it's not safe, we don't want to build a repository there. We have to gather the data to make those kinds of determinations.

The data we're going to gather is going to be used to evaluate the natural barriers at Yucca Mountain and provide us with information for performance assessments and engineering designs.

We need to know how the repository is going to operate and the only way is by gathering data. There's our exploratory facility. You'll see all this tomorrow. This is just a little proof of what you're going to see and, of course, the crest of Yucca Mountain.

Our site characterization program revolves around two aspects. Our surface-based program is very extensive and our tests are underground for the exploratory shaft. Certainly we're going to see the intense, close-in studies as we do the exploratory test and we're going to develop it.

Look around the region. We have lots of stuff planned. Maybe not as much as some people would like but we believe we're going to scope the area. We're always willing to listen to other thoughts, though.

With characterizing a geological site like Yucca Mountain, we will be looking at all these activities. Our plan is to do both; to move on with the surface-based testing and at the same time we're moving on with the exploratory shaft facility.

The NRC data from both is needed in the license application. We concur with that and we're pursuing both of those.

DR. CARTER: Can I ask you a question? Does the word "exploratory" give you a problem in this since that facility will become part of the exploration?

DR. GERTZ: That describes what we're going to do. It is exploration.

DR. CARTER: It's the first part of what your doing?

DR. GERTZ: The second stage would be ventilation shafts in the design, Dr. Carter, and at that time, we might have to do something different.

Initially they're for exploration and only if Yucca Mountain is suitable would they become part of the repository.

Just to expand on our exploratory activities, we have 6,300 pages that lays out what we know about the mountain.

We talked a little bit about surface-based. We are putting a lot of emphasis on surface-based testing. Ninety-four of our study plans is more details up to 200 pages that describes the 106 activities in the very comprehensive plan. So we have 94 of these for surface-based and 12 for the testing and the exploratory shaft. Five of these plans have been delivered to the NRC. Three of these are on the way to NRC.

We're working on 80 of these plans. This is our next level of detail as to what we're going to be doing with our studies.

Before we start our studies, Marty alluded to dry core and dry drilling. We agree that's necessary. We have a program to assure ourselves that we can obtain dry core. Dry coring obtains a depth that has not been done. We have used chips but not cores down deep and dry. We've undertaken a program in developing equipment. We've conducted some tests in Utah. We think we have developed procedures for water-line coring and blowing coring. Six inch cores are being brought to the surface purely by air. Here is what this equipment looks like. It was at the site in Utah.

If it's blowing core, it would be drawn from below ground as deep as 2,000 feet through this air hose into a sample collector. Line would be the traditional retrieval but what is not traditional is drilling dry without any fluids. We had hoped to take that technology and practice it on tuffs.

Our goal was to move down here about five miles from Yucca Mountain, five miles from the repository, and conduct some prototype tests in tuff to the depth we're going to use in our other projects.

This is the control area. We hope to be here. Tomorrow I would like to be clearing dirt there; however, we thought we could do it under a clean-air permit that the Test Site uses. They drill hundreds of holes every time this year. They would litigate it if we tried to do that.

As a result, we filed an amended permit that they are looking at but it's been two months and I've been told it will be a couple months before we'll hear from them. We're unable to do work today.

We'll probably find a site in Utah where we can go ahead and further optimize our procedures, optimize our equipment, but we're moving along in the prototype drilling and it was exciting to see new work done.

When I follow-up on the surface-based testing, let me point out that we really have five aspects. We have the drill holes. We have 329 holes outlined in our program. We're going to do trenches in areas around faults. We have monitoring going on right now. We've been monitoring the hydrologic systems, infiltration processes, and seismicity.

We're not there quite yet. We're doing some maps of the areas out there and we're always monitoring climatology. This is going on right now. We're doing laboratory tests also.

Let me just point out, our near term schedule for surface-based activities, we would like to start just after October both at Midway Valley and in Trench 14. We then do some additional trenches and then we get on with our drill holes and then we begin our deeper unsaturated drill holes. That's our present plan.

Should the plan come to fruition, we have anywhere from six to eight drilling rigs in operation in 1989 at the site collecting new data and that's our goal. In 1991 we would increase the number of drilling rigs and activities like that.

Let me now switch to the exploratory shaft. In parallel to the surface-based program we're moving ahead, planning designs, and hopefully in the near future, site preparation.

The exploratory shaft consists of two mined shafts. Our shafts are 12 feet in diameter and 1100 feet deep down to the repository drifts. That's our overall layout for the exploratory shaft.

To see it at the surface, it would look just like many other mining activities that go on in Nevada. Our approach would be drill, load, blast, and muck.

The key difference from other mining activities is that we're not in a race to go down below. We're going to go very slowly.

After we drill, blast, and muck 78 feet, the scientist's will come in there, characterize the rock thoroughly for faults. They'll do whatever tests they will need to do. We will then drill, blast, and muck again and we'll move down the shaft that way.

The exploratory shaft provides unique opportunities for us. We can examine the real rock that we're trying to understand. In addition to that, it will test the response of the rock mass below ground to openings that are almost identical to the repository. We'll have time to gather information as to the performance and rock characterizations as well as to construction of the repository.

Let me then start our simplified network as to how we can start work. The exploratory shaft is one of our major projects. We have started here in April our Start Title II Design. Title II means construction drawings. We're doing that so we can begin preparation of roads after we begin. We will build the pads and roads. The first thing we will do is the drawings and examine the conditions. Then we would get on with starting the collar. We don't know about the time frame for these. You don't see any dates on here. All we know is we start at here. I'll talk about them briefly in a minute. We know we have accomplished some of this and we have submitted our plans.

I want to point out one thing. This is one of the most important charts we have in order to gather new data. This is my check list. I have to satisfy these prerequisites in order for the Department to get out and gather new site characterization activities.

Let me address them one at a time. First of all, land access. The land at Yucca Mountain includes land under control of the Department of Energy, the NTS, land under control of BLM and it includes land at the Nellis Air Force Range which is controlling land but in BLM jurisdiction.

We have gone through all our procedures. We do have access to the BLM land. We don't have full access to the Air Force land. We're about three weeks away. We're waiting for one letter from the Air Force Base. I believe within a month that will be taken care of.

We have to obtain some permits from the state. We have to obtain a surface disturbance permit before we can even make a road for new site activities. We submitted our application 18 months ago in that area. The state is looking at it and examining it but we don't know what that's going to hold in the future.

The next item would be that he NRC would have to review SCP. They will provide us with their documentation the end of July so we think that's well underway.

The study plans for whatever activities we're going to do must also be reviewed by the NRC, the study plan for the specific activities. NRC has some of our plans now. They'll be provided additional ones very shortly. Particularly the ones for the trench, we want to get started with that.

We have to have our engineering design complete and documents that will not effect our site characterization activities. The way we do that is design control process by our activities. We just can't go out to the site of the mountain. We have a lot of control as to what we're doing. We can't even build a road or put water on the road. We have to have it well documented.

Another thing we must accomplish is have a fully qualified Quality Assurance Program accepted by the NRC. I'll expand on that a touch later but if you wonder why we're not gathering site activities today, I have to accomplish these things first.

In my view, five of these six things will be accomplished by late summer or early fall. To me it would be a travesty in this room if we're unable to gather new site characterization data because of the state and their reluctance to issue both a Clean Air Permit and the Water Preparation's Permit. We want to get out and gather new data and we're eager to work in that area.

DR. CARTER: As far as I know, your program, as well as the NRCs, where they interact a schedule well in advance, some of these dates may change but I gather there is no such program and scheduling and so forth on a formal basis with the state as far as land access and this sort of thing, is that true or not true?

DR. GERTZ: The state wants to undergo a drilling probe and they're concentrating on looking at the SCP in this interim but we have--there's no commitment for them to provide permits on a certain date or things like that.

DR. CARTER: You don't have a schedule?

DR. GERTZ: We have a schedule when we're going to submit things to them. They do not agree with us when they are going to submit them back to me.

DR. CARTER: This activity has been ongoing for quite some time for a number of years. State activities have taken some six years and it seems to me that both of you are sort of holding. They can't get on the Test Site and now you can't get on the Test Site so nobody can get on the Test Site.

DR. GERTZ: They're welcome to. You've heard Carl. They're welcome to do anything they need to do under land control.

There is a certain part of the Test Site controlled by Nellis Air Force Range that we don't get onto. That's normal security to the east of Yucca Mountain and to the north of Yucca Mountain where, other than isolated seismic stations, we're not allowed on there either. It's not an area--

DR. CARTER: I understand it but some of them don't need to get on it perhaps but it bothers me. This whole technical and scientific program is probably in hostage.

If you can't go on to do trenching, you really have no control over that schedule and I presume--

DR. GERTZ: That's true.

DR. CARTER: Somebody should be working on these differences. Some of them might be frivolous.

DR. GERTZ: We're certainly trying to work with the state--even a prototype drill--in order for us to improve our quality and optimize our procedures.

We're trying to work with them but, of course, the state has other interests and other issues that they like to present.

DR. PRICE: Which is the six activities that you do not--

DR. GERTZ: Obtaining a permit. If you read the paper today, it outlined that the state may not want to address these permits because--Quality Assurance, certainly you've heard a lot about it.

It's a scientific program but I want to point out that this is the first time that I know of that details are going to be applied to scientific processes to the natural barriers. It's going to be much like what they did to a reactor or to emergency cooling systems. They're going to have to undergo the same kind of scrutiny.

I want to point out it's not only important that we follow the scientific plans and the technical procedures, we also have to follow our quality assurance plans. Only when both are adhered to can we begin scientific investigations and only then will we have data suitable for licenses.

We made significant steps along this area. The NRC has approved our plans. Our plans have been submitted and approved by the NRC. We're training people. We hope by the end of the summer we'll have a fully qualified program. That's our goal. We're moving along. We have a ways to go.

Here's some of the percentages. Over 97% of the personnel have been trained and are qualified.

DR. ALLEN: What personnel?

DR. GERTZ: Scientists. We have to have verification that a reviewer of a technical document must be qualified so everybody on the project that is contributing to a scientific document has to be certified that they have the correct background to participate.

DR. CARTER: How does the certification work?

DR. GERTZ: It includes technical experts in the field that--it's part of the NRC which states the quality assurance program requires qualification of personnel.

DR. PRICE: What are the arguments?

DR. GERTZ: The NRC are the regulators and they say this is how it's going to be as to what we have to do.

As I say, the fact that we have 99% of the people qualified leads me to believe the scientists and engineers and the NRC have reached an agreement.

DR. PRICE: What do you think the cost ramifications would be? Double? Triple?

DR. GERTZ: I really can't say. It is expensive. No doubt about it. It costs money to do all the documentation.

DR. ALLEN: If it were not for the NRC, as you state, do you think you could do it more efficiently in a different way?

DR. GERTZ: That's somewhat of a rhetorical question. Many things need to be done whether it has to be done in the depth of the recommendation and all the proofs that you have to have, it could be a debate and therefore more efficient but right now I don't think it's a detriment for us getting on with the problem.

We'll follow the procedures but I think we're moving in that area right now and the scientist's have begun to accept it.

We just went to Lawrence Livermore National Laboratory and they got some excellent markings who audited them.

DR. WILLIAMS: Did the NRC qualify your personnel?

DR. GERTZ: No. They approved our program. The fact that we're doing it and the checklist that we go through, they accepted our program. They accept our program. We implement the program.

DR. WILLIAMS: Who verified their personnel?

DR. GERTZ: You'll have to ask the NRC.

DR. CARTER: In terms of numbers or percentages, how many people are you talking about in the scientific system that are qualified in terms of quality assurance?

DR. GERTZ: I'd say in the four to five hundred range. The question was how many people were qualified and I'm saying in the four to five hundred range from our documentation.

DR. CARTER: I presume this is a continuing program that you continue to need them and I suppose there's a great turnover?

DR. GERTZ: We'll qualify. Those people who are going to be on the drilling rigs as the geologist's move to the field, they need the proper education and training and we have to document that. You have to document that.

The reason being is quality assurance is necessary in this program because we're licensing a repository. We're in a court of law. We have to adhere and answer to the procedures or else it will be worthless in a licensing process. It's not unlike the courtroom analogy and you have great evidence and you're ready to prosecute and somebody finds a flaw in your search warrant and all the evidence gets thrown out.

It's the same thing for licensing activities. It's not data unless the NRC says it's data. I can't say it any simpler. That's the regulation of this country and that's what we're going to have to do. It is the rules that we have to live with today and I think it's obtainable.

DR. CARTER: Of course the recommendation and work may not be mutually exclusive.

DR. GERTZ: Well, we think you can document it. We're moving to that. There's always been debate. It's going to inhibit scientific investigation. We're allowing for these kinds of activities to occur. It's a matter of the scientists and the quality assurance's professionals meeting of the mind and we're both learning so we've come a long way.

I guess that was my goal and we've come a long way because we need to answer this question. We need to get out in the field to determine if Yucca Mountain is a safe place for a nuclear repository. That's our whole goal and I'll accept any more questions now before I turn it over to Max.

DR. PRICE: This qualification of personnel involves Government personnel, it involves all personnel?

DR. GERTZ: Anybody who is involved in the project whether it's review of the document, the preparation of a document, the gathering of field data, the release of field data; anybody that's involved.

DR. ALLEN: Not state personnel?

DR. GERTZ: No, not state personnel. This state does have it's own quality program. It will not be audited. It will not have the same depth but they will not be audited by the NRC. That's not unusual for a licensing environment, those who are presenting the evidence might have to answer those--

DR. DOMENICO: Carl, will we learn about the 106 test plans?

DR. GERTZ: Yes, sir, during the course of today's presentation and tomorrow at the site, details of that will be addressed.

DR. DOMENICO: Can I ask a question? Can they be conducted in a series or--one hundred and six seems an awful lot.

DR. GERTZ: Both.

DR. DOMENICO: I'm curious because the unsaturated zones are so mysterious. My understanding is that there's probably some of that that is going to be running as pilot plans where the theory is not well developed before the actual plan is brought to the block itself.

Do you have a considerable number of those?

DR. BLANCHARD: That's true. We have a prototype program which Carl has alluded to. We're running mock tests or prototype tests which, once developed and documented, will become part of the procedures for the testing program at depth.

DR. DOMENICO: So a lot of verification has got to take place because you actually bring the methodology in the--

DR. GERTZ: Some of that we've been working the last two years developing procedures, developing equipment that will be used at Yucca Mountain. That's been about a two million dollar program.

DR. DOMENICO: Thank you.

DR. GERTZ: Thank you and with that, I'll introduce Max Blanchard who will continue the presentation.

DR. BLANCHARD: Thank you. I work for the Yucca Mountain Project. I'm a Geologist and I'm a Manager of the Regulatory and Site Evaluation Division.

What I'd like to do is to present an overview of the Yucca Mountain site so that you can get a feeling for what's going to develop over the next two days and; secondly, I want to talk about your characterization for Calico Hills because there was some confusion about that yesterday.

The topics in today's briefing, geology and volcanism and seismicity, and in the afternoon we'll hear about hydrologic conditions at the site and then we'll discuss these 106 study plans and site characterization plans.

Tomorrow's topics covered on the field trip include geology and hydrology in the morning. The hydrology will include the unsaturated zones and the saturated zones in the test program. Then in the afternoon at the Test Site, we'll go over to the Management Facility.

As Carl mentioned, we'll talk about the dry drilling status and maybe you'll see a video. I'm not sure. I believe we have a ten minute video.

Now, we're right on schedule. I'm just starting at 9:15. I'll try to keep the talking on schedule to the extent that we can.

The first speaker will be Dave Dobson. He's a Geologist, and Chief, in my project. Dave will talk about the description of the site. It will include the geologic setting, the tectonics and a discussion of our knowledge and understanding of mineral resource potential, such as it is.

Then we can expect to have a break around 10:30 and Bruce Crowe from Los Alamos will describe the volcanism in the vicinity of the site. He will also describe our approach for assessing volcanic hazards.

In this presentation he will review our previous assessments. He'll discuss recent information about the volcanic centers. This will include certain studies of Lathrop Wells. He will describe the approaches we have of improving, and sharing with us, his current assessment of volcanic hazard at Yucca Mountain.

Then Jerry King from Science Applications International will describe the seismicity in the vicinity of the site and he'll also discuss our approach for assessing the seismic hazards. He will also talk about the ground-motion hazards and the faulting hazards and the interactions with the ground water itself.

At approximately 12:00 we hope to break for lunch and then at 1:15 William Wilson and William Dudley, who are Hydrologists with the U. S. Geological Survey, will discuss hydrologic conditions at the site.

This will include the regional hydrology and it will include site hydrology of the saturated and unsaturated zones at Yucca Mountain. Also a discussion of paleohydrology and paleo on future climates.

A special talk with William Dudley about the stability of the water table and the evidence of vast discharge.

We expect to have a 15 minute break around 3.00 and then at 3:15, Jean Younker, who is a Senior Staff Geologist at Science Applications International, will discuss the site characterization plan for the last five years and will describe the plans for site characterization.

She will review the purpose and principles and give you a review of the site studies that will include the logic with relationship to this and the activities and how they have developed.

Then I will come back around 4:45 to describe our logistics for the field trip and I have some hand-outs to give to you then.

Now, what I would like to do, because I have a few minutes before I introduce the next speaker, is to talk with you a little bit to clear up some confusion.

SCP, as it exists now, has a series of drill holes. Jean will describe more to you later about that when she gives her presentation but there are regulatory limits. They must be drilled in such a fashion when you develop a repository. That's the current program for acquiring information in particular with Calico Hills.

Now, in the consultation draft that was released a year ago, as you may or may not have recalled, there was a proposal to extend ES-1 into Calico Hills.

Now, in the process of converting from the consultation draft to the statutory draft, the Department entered the formal agreement with the NRC Staff to prepare a risk analysis prior to making a decision to penetrate to Calico Hills from the exploratory shaft. That's where some confusion may come up or someone might think there's no program to characterize Calico Hills.

Now, what we passed out--I'm not sure what they are--is a copy of a briefing that I made in February which summarizes the agreement that the Department has to do this risk benefit analysis and what I would like to do is to just share the highlights of this agreement with you so you can understand the Calico Hills program.

This was a briefing in February to the AWW, which is a committee that oversees the Technical Staff that works for NRC.

To summarize the objection, the DOE--it was objection #2. It was tied to the exploratory shaft at Calico Hills. The Department's approach was to rewrite 8.4 and to defer the decision to penetrate with ES-1 pending the development of this analysis.

To summarize the NRC objection, they felt that the need had not been established to ES-1 into Calico Hills. Their recommendation was to consider characterizing the Calico Hills without penetrating the barrier between the repository horizon and the water table and to show why the benefits outweigh the potential adverse impacts of penetrating the Calico Hills, rather than obtaining the necessary information by alternate means so that's what we're working with so it's been an objection on the consultation draft.

Now, in writing the SCP that the Calico Hills was a prior area barrier, we had to have an excellent understanding of the potential of that and so that is embodied in SCP, it's embodied in the study plans and the studies better described as well as the activities.

The decision on whether to proceed within the Calico Hills has been deferred pending completion of analysis. The data we need from Calico Hills; what alternate means of obtaining the data; the benefits of obtaining the data from the Calico Hills and the risks to site performance by obtaining data.

They'll be three aspects to that report. Evaluation will assess first the need to reduce uncertainty in both hydrologic and geochemical. Parameters are identified in allocation process and they work their way right into the total system.

Hydrologic parameters and processes include Matrix vs. Fracture Flow; the actual value used in travel-time calculations and identification of flow paths and travel times within the repository.

Radionuclide retardation, we have to know the distribution and abundance of the minerals and especially those where there is clay or whatever they are.

A second component will be the need to obtain representative data on the Calico Hills.

The NRC's asking for alternative methods and we're going to discuss obtaining information from Calico Hills outcrop; obtaining information from surface-based programs as it's correctly described in 83 of the SCP reports, and the possibility of drilling from within the main ESF Test Level in Topopah Spring from the exploratory shaft and then the possibility of excavation into Calico Hills from ES-1 and finally, the most important part is assessing what the potential impact of penetrating into the Calico Hills.

Now in summarizing, the design, the engineering design to the exploratory shaft and the underground layout still will retain the capability to do so from the engineering and operation standpoint. We have that capability. We will do this risk-benefit analyses and then we will meet with the NRC before we make a decision.

Are there any questions?

DR. NORTH: Can you give us the time schedule?

DR. BLANCHARD: It's being prepared now. I guess within the next two or three months it would be undergoing technical review in the Technical Headquarters.

DR. NORTH: Thank you.

DR. DOMENICO: You may not look at the Calico Hills if the risk factor so indicates?

DR. BLANCHARD: I'm sure that is a certain possibility. I think from the performance standpoint, the principle barrier is something you can't penetrate frivolously. Our Service Program will have these large barriers and the holes will be pillows. To the extent that will satisfy all of the people's criticism, I'm not sure. It depends upon the debate.

DR. WILLIAMS: The benefits are obvious. Can you say how you will look at the risks other than the general comments you already made?

DR. BLANCHARD: That will be discussed when Jean gives her presentation. You'll just end up taking five minutes to discuss that. Will that be alright, to delay that to her presentation?

DR. WILLIAMS: Yes.

DR. BLANCHARD: Are there any other questions? If not, then we're a little ahead of schedule and I'd like to keep moving.

I'd like to introduce the first speaker, David Dobson.

DR. DOBSON: In general I talk a little more loudly than Max but it's kind of hard to tell.

I work as a Geologist, and Chief, at the Yucca Mountain Project Office.

What I'm going to present today is an overview of the geologic and tectonic aspect of the Yucca Mountain site including some discussion of the regional setting and some more specific discussion of the structural features in the vicinity of Yucca Mountain.

As I mentioned, this is more or less an overview level and it's intended a preface to more specific briefings that I'm going to get later this morning and later in the field.

Following this presentation and in the field we're getting briefed from a number of our investigators who are working in the field on various topics including the details of the structural features in the region and stratigraphy.

We have a number of people in the audience. There are representatives of Los Alamos and the U. S. Geological Survey in the audience and they're available to help answer questions at the break and if you ask anything that I don't know, which is certainly possible, we'll be able to call on them for some help.

Just to reiterate, the scope of this presentation is an overview of the regional geologic and tectonic setting of Yucca Mountain and some of the sources of geologic data that we've used to compile the data base that we have now.

A little more on structural features in the vicinity of Yucca Mountain and some discussion of site stratigraphy on two basis; parts relevant to the rock properties and one relevant to the geochemistry, as opposed to theoretics and laboratory of geochemistry that we're discussing that won't be discussed in my presentation today and finally we'll have a view of the natural resource potential in the Yucca Mountain Region.

Again, we're going to start on a regional level and talk about the South Great Basin, discuss in very brief forms, as I mentioned, some of the seismicity in the region and then just a little bit of general discussion about the general geologic description of the region and about the major structural features, and the relationship of structural zones and seismicity.

This is more or less a modified map of the South Great Basin and it shows Yucca Mountain and the Nevada Test Site and some of the major features in the Western United States.

Basically the purpose of this was to emphasize the boundaries which include the Sierra Nevada and the Death Valley, Mojave area. We'll talk in just a moment about Walker Lane and perhaps we'll address some of the questions that were raised yesterday.

This is a map that shows the Walker Lane structural belt, more or less, and some of the major faults that are associated with it and I use that term a little bit loosely. As Michael List mentioned yesterday, it's a structural feature well north of Reno down to the Las Vegas area and I'm not sure. I've seen recent publications that say Walker Lane should be extended to Mexico.

It's clear--and this may be relevant to something Dr. Carter used yesterday--that there has been a lot of activity in the northern part of the structure, the northern part of Walker Lane north of Topopah, and the major features between Las Vegas has been relatively quiet and it's generally considered to be--I'm not sure if it's officially inactive but relatively quiet.

Let's go ahead and go to the next one. This is a map again which--and this is the extent to which I'll discuss seismicity. This is a map of major events in the Great Basin in California. It shows the relationship of seismicity to the major features and also it shows the Central Nevada Seismic Belt here. The Nevada Test Site and Yucca Mountain is relatively quiet, as several people mentioned yesterday.

We're going to move to a little more detail and talk about the Yucca Mountain Region a little more specifically and within this discussion we'll again focus on the general setting; the structure; and then the stratigraphy properties and then some aspects of the natural resource potential.

Let's try the photo first. This is an air photo of the Yucca Mountain Region. The Yucca Mountain Region is shown in the foreground.

DR. ALLEN: What direction?

DR. DOBSON: Northeast across Nevada Test Site. The rocks in the upper left part are parts of the--Yucca Mountain runs across the central part of the photograph.

It was discussed yesterday and also today about the Cinder Cones. This area is 3,500,000-3,700,000 years old and I'm not sure if it's visible here. Is that Lathrop Wells? Why don't we real briefly put on the first graphic features?

We have marked the approximate boundary of Timber Mountain

Caldera. We also have Fortymile Canyon, which is the major discharge wash in the Yucca Mountain Region. This contains a number of other features, some of which you heard yesterday. Calico Hills is immediately east, northeast of Yucca Mountain, and Shoshone Mountain, which is the site of some mineralization and we might come back to that briefly later on.

I'd like to take a moment to discuss sources of data. We believe we do need a considerable amount of additional data with respect to site characterization. We don't want to leave the impression that we don't have any data.

In general geological terms, Yucca Mountain is already one of the more characterized in the Western United States with the various studies that have been done. There is some degree of confidence that we're beginning to understand the geology and we've identified the areas that need additional study.

A 70,000 foot core from drillholes is at or near Yucca Mountain and that comes from 182 different drillholes that are within 10 kilometers of the drill site. We have geothermal and geophysical logs of those drillholes. We have 23 trenches within 10 kilometers and that's a little misleading. There are a considerable amount of additional excavation pits in the area. We have a relatively extensive monitoring network established at Yucca Mountain.

DR. CORDING: I have one question. Is that 70,000 feet of core? How much of that core is available for inspection and where is it located? DR. DOBSON: The majority of that is in the sample, I believe, and I understand that the procedures have all been improved. I believe the core is inspected. We had a long process over about the last year of transferring the core. It was stored in the U. S. Geology in Mercury. It's been transferred, logged, and basically it's now available for inspection and distribution again.

DR. GERTZ: We'll see some of it tomorrow.

DR. DOBSON: In addition to that very specific information, we have a number of relatively detailed Geologic Maps--1 to 40,000--by U. S. Survey, 1984. We have the original maps of Lipman & McKay, 1965--1 to 24,000. That was one of the first sheets that described and detailed the Nuclear sequence. It is one of the better described in probably the world, I guess, and we have a 1984 report by Scott & Bonk, which is a relatively detailed map that you will see, if you haven't already. We'll see it tomorrow.

We have a variety of types available. We have both regional and local geophysical studies including low-altitude aeromagnetic surveys, seismic reflection and refraction data, and extensive gravity network and we have additional data in the form of electrical resistivity studies so there is a fair amount of documentation available to help us describe the site.

As I mentioned just briefly, this is a sort of presentation of the location of existing surface-based activities or things that have been done out there. It shows the distribution of the drillholes, trenches. There are various drillholes. Forty of the 180 are deep holes. The majority of the remainder are shallow holes including in the immediate vicinity of Yucca Mountain, an extensive network of shallow unsaturated zones that will be talked about tomorrow where we have some interesting results in terms of infiltration but there is a rather large data base in terms of data.

DR. CARTER: What about the availability? Is it assessable by computer? Have you gotten that far along with it?

DR. DOBSON: The current data is published and; of course, anything that's published is available upon request. There is, of course, at any one time a large amount of data that is being published between the time it's being collected and Carl addressed that earlier today, that we're trying to make systems to make that type of information more quickly available to people that are interested.

This is a map of the Yucca Mountain Region. Yucca Mountain is in the lower center of this map and I put it up to show several things. One is the relation from Yucca Mountain to the Timber Mountain, which is the round circular feature in the middle of the top of the map. Timber Mountain is the source of the rocks that are exposed at Yucca Mountain.

The tuffs at Yucca Mountain in the Timber Mountain area range from, I think, in the vicinity of 16,000,000 to 9,000,000 years old. From Calico Hills, we will discuss that a little bit later on.

Just to point them out again, the cones that we saw in the air photo are created here, here, and here and Bruce will talk about what those mean in terms of site characterization and potential effects on the repository.

The young Lathrop Wells is at the south end of Yucca Mountain. Bare Mountain is the large complex across Crater Flat to the west and there was a question yesterday by Dr. Domenico, I think, and I wanted to use that map to take an opportunity to point out that we do have extensive--

DR. GERTZ: The mapping gives us information on distribution of rocks. We have all the drilling information on Yucca Mountain plus--

DR. DOMENICO: Any cross sections for those?

DR. DOBSON: There are regional cross sections available. I don't know if we have them in the presentations right now but I see Rick nodding so that's probably a yes.

CHAIRMAN DEERE: Is this map the 1984 map by USGS or by Scott & Bonk?

DR. DOBSON: It's based on Lipman and McKay in the north end and mapping by Bob Scott. I'm not sure where this map is published. It is a U. S. map but I'm not sure of the publication. I can definitely check that out on the break.

CHAIRMAN DEERE: We'd like to have that, if we could.

DR. BLANCHARD: Everyone is going to get a copy of that map. It's part of the package that's going to be handed out in the field trip.

DR. DOBSON: Let me see if there is anything we want to mention. The FortyMile Wash, which comes from the north end running north down Yucca Mountain, we're going to go into a little more detail.

No, to talk about some of the local structures at Yucca Mountain.

I think the order of this is slightly off. What we're going to do first is look at a map of Yucca Mountain and look at the faulting distribution that has been mapped at Yucca Mountain; then a northwest-southeast structural cross-section which is drawn by Bob Scott and based on their detailed surface mapping and then we're going to take a quick look at some of the alternative models that have been proposed by the DOE for the interpretations of the geologic relationships at Yucca Mountain and the Yucca Mountain Region.

This is not very good but it shows the major faults that we want to talk about. Many of these were talked about yesterday. What this map shows primarily is the distribution of the faults at Yucca Mountain with the possible exception of the Ghost Dance Fault, which we don't have any evidence of.

There are tabulated somewhere on the order of 32 faults and there are a number of them that John Bailey used. The Windy Wash Fault is currently the only fault that we know that has some displacement and it's the latest displacement in the three.

The Bare Mountain, which was on the previous slide at the west end on the west side of Crater Flat, it has to have polished displacement on it.

We have, as you will hear from Jean this afternoon and Ken Fox in the field, a rather extensive program planned to characterize on all the faults.

DR. ALLEN: Is this map different from the fault maps we were shown yesterday?

DR. DOBSON: I don't believe so, no. This is, as we say, a cross-section that was shown on the previous feature and I just wanted to bring it up and go through sort of briefly some of the major features in some of the cross-sections.

I'll show it to you in two parts. It's given to you in two parts also. This goes from the northwest to the southeast. The Windy Wash Fault is the one fault that we know has gone and it marks the west end. The other major faults are all shown as well as all the faults that have been referred including the Fatigue Wash Fault. The Ghost Dance Fault on this cross-section is nowhere around here. I'm not certain where but it does include the Ghost Dance Fault.

A couple of points to make--and I believe this was said yesterday--but nearly all of the faults are on the west side, normal faults, and we do have evidence in some cases of lateral--we're trying to determine what types of offset have occurred on these faults in terms of cross-sections but we have such details, surface relationships that--

DR. ALLEN: Is there any direct evidence for that or is that an interpretation?

DR. DOBSON: I believe that's basically an interpretation. They are at the surface and there is a limited amount of sub-surface information. Some of these faults have been encountered in drillholes with depth and I'm not sure whether we have actual knowledge whether they're shallow.

Now, it extends just east of the Solitario Canyon Fault to just past the Ghost Dance Fault, this cross-section.

Is there a scale here? I think it's on the other half of the cross-section but it would be something like a cross sitting like that.

DR. CORDING: On that drawing on the right there's a couple of lines which is known as faults with minor dips, displacements; is one of those that unnamed fault that was referenced--

DR. DOBSON: No, both of those are shown on the geologic map by Scott.

There are small fractures with offsets of less than a meter. This cross-section runs south of Coyote so those are not shown on this cross-section.

This is the rest of the cross-section from northwest to southeast. It starts in an area of what Scott--faults are based on relationships that have been mapped and drillholes and inferred from a few surface outcrops.

DR. ALLEN: Are they schematic?

DR. DOBSON: I think semi-schematic? Some have been identified and they are noted as faults with minor--basically they were mapped on the basis of drillholes encountered. Each of these faults have not been mapped.

DR. WILLIAMS: You're not sure they're faults; they're offsets?

DR. DOBSON: They're interpreted offsets.

We have a few more that I'll go through on this cross-section; several more of the more significant faults; the one's that have names.

The Bow Ridge Fault, that we will see in the Trench 14 Series tomorrow in the field and then the Paintbrush Canyon Fault and the Fran Ridge Fault.

I believe that the Paintbrush Fault will be discussed in some more detail in terms of seismic activity. It's one of the largest offset faults that we have mapped out there and so it does come into play in the seismic analysis.

Again, just for information, the water level is shown by the dotted line across here. It's perhaps a good cross-section to show the flat grading at Yucca Mountain and south of Yucca Mountain.

To discuss about some of the alternative conceptual models of the faulting at Yucca Mountain, we wanted to spend a minute or two on that.

You heard some discussion of this yesterday in terms of alternate ways and what we have on these views; some of the information that's contained in the site characterization in terms of geometry and mechanisms; so the numbered things that I'm going to go through constitute a sort of combination of alternatives for both geometry and mechanisms and that is some difference.

Mechanisms may result in the same geometry so we're going to look at a figure in just a moment. I'll go through them briefly. The first possibility is planar-rotational faults. These are faults which extend to depths of 15 kilometers or more. A possible variation on this is multiple generations possible.

A second possibility that was discussed yesterday; that some of the faults that have been noted at Yucca Mountain are detachment faults. Most of the north trending faults that we see at Yucca Mountain will be listric to west dipping low angle faults beneath Yucca Mountain and we'll look on that in a cross-section in just a moment. Some of the northeast trending strike-slip faults might be shallow boundaries of these faults. They might make it where the faults are moving away from the surface.

A third possibility is that the faults that are related to the Walker Lane System; and what results is you have a system of fault strands. In a case like this, the fault would still be extended throughout the upper crust. They might, in a case like this, have a significant strike-slip component. The component that we noted to date are nothing but you don't have sufficient data right now that we can say we don't have any movement.

The fourth model is that there are Walker structures, lateral structures, that are concealed beneath the detachment fault at Yucca Mountain and again we'll look at this on the cross-section and, finally, you might know where the normal faults are, which are basically the same geometry as was suggested in number one.

You get into cosmic sort of explanations. We're going to look at some of the cross-sections that you can draw your own conclusions based on interpretations like this and I want to point out that eventually the program is carrying virtually all of these as possibilities.

To summarize, the models that I just finished talking about, the Planar Fault Model, which essentially looks the same for Numbers 1, 3 or 5 that we just went through which looks like this--as I mentioned, it's also conceivable that you can have multiple generations of faulting.

A second possibility is the detachment model. In a model like this you might have the fault that shallows to the west. It's a drawing on this cross-section.

Finally, the last geometric representation of the various models that we talked about is shown here in Model 4 where you have the possibility of a Walker Lane type structural system that might be concentrated in a single zone or might be concealed underneath a detachment fault.

This, I think, would be not to different from the model that Rich talked about in concealing faults. There are many detachments in the Yucca Mountain Region.

I did want to make one final comment. Whichever model you choose is going to have an effect on the types of seismic analysis and the types of faults that are likely to occur are contingent on the faulting model that you believe is appropriate to the site and; therefore, it is important to discriminate between these and to decide which one is more appropriate for doing a seismic analysis and that is a significant part of the program.

We're going to talk in a little more detail about some of the stratigraphy of Yucca Mountain and a little discussion about the property variations in the rocks at Yucca Mountain including discussions of the rock properties and that will be quite brief as many will be at the site.

This is a summary of the stratigraphy of the site and it's divided into several units because each of our groups have a need to characterize the stratigraphy in various ways.

The left column is the main rock stratigraphic unit that's been compiled by the work of Scott and the other workers in the area and contains the familiar names including the Paintbrush Tuff, which consists of Topopah Spring, Pah Canyon, Yucca

Mountain and Tive Canyon. Tive Canyon is strongly welded. Pah Canyon and Yucca Mountain are unwelded and better tuffs. The tuffaceous beds of Calico Hills are shown on the left. In the Calico Hills, of course, ash flows and bedded units, which are unwelded invariably but are in many places still glassy.

Below the Calico Hills is the Craterflat Tuff and we have some more of the definitions within each of the member units.

I don't intend to go through every aspect of this thing but we see the way the units are compiled in terms of characterization.

A good example is within this part of the section of the Calico Hills and Prow Pass, they are basically similar in terms of properties so they've been combined and, of course, as we go through the site and more detailed information about the properties of those units, you may see more details if such information seems to be appropriate.

The third column in here talks about the mechanical units. That is the way the rocks have been broken up in terms of the thermal mechanical properties and the main thing that I want to point out on that chart is the potential repository horizon, which is the Topopah Spring, which is relatively low within the welded tuff. The Topopah Spring, TSw2 is thinner than the TSw3.

DR. ALLEN: Can I ask a question? Of course more of the exploratory shaft will be in the Topopah Spring. Does it have any horizontal bedding where faults can be easily recognized or is it basically a massive rock where faults will only be recognized by the fracture itself?

DR. DOBSON: There is some internal recognition but as far as details of it, I think you will probably find it may be different and that might be a better question asking Rick.

I might note that one thing that I didn't discuss is that Topopah Spring is a pretty big unit on the order of 1,000 feet or more. The regional distribution of that map of that unit suggests it was a very largely represented unit when it came on the order of 1,200 cubic kilometers and it's fairly extensive and again we can discuss the distribution of the unit in the field tomorrow, if you would like to talk about that.

CHAIRMAN DEERE: What was the thickness of TSw3? Did you say 50 meters?

MR. DOBSON: That's a number I'm not certain. It's on the order of 50 to 100 meters. It's less but there are variations even within the TSw1.

What we're looking at now is again just a depiction of Yucca Mountain with the location of some of the drillholes that have been used to compile these. That's what we're going to look at here real briefly.

The deepest hole is USW G-1, which is southeast of the repository and this was mentioned yesterday. It is the only hole which has gone through the conduction as it was interpreted a fault in the vicinity of 1,000 meters and went into gold mines and continued for a couple thousand feet, something in the order of 600 meters and we'll look real closely. I think we're going to look at the north-south section through G-2, G-1.

Again, you can see the stratigraphy that we talked about on the right side of this diagram; the Calico Hills, Craterflat Tuff formation and some of the other rocks. Well, some aren't really a cross-section. You don't see any bottom to the section. We're west of where we encountered the rock and data. In this area it might be 10,000 feet thicker here running under Yucca Mountain. You can see, for example, that the Calico Hills is thicker to the north and thins to the south.

In fact, that is the general characterization of the tuffs at Yucca Mountain because the source was to the north and they tend to get thinner as we go south. I think that was the proposed approximate interval. This again was just put in here very briefly.

This is the east-west section. I put it on here to emphasize that we did encounter the dolomite in the bottom of P-1. We got something on the order of 500 meters or 550 meters of dolomite on the bottom of that hole and it shows the east-west correlation. These holes are not to scale. This are is considerably east of H-4 and H-5.

DR. ALLEN: You say it was in the fault?

DR. DOBSON: There was basically several reasons. The interpretation that lead to drilling suggested there was dolomite and we don't have real good data of the hole because that was a rotary hole but interpretation of the cuts there suggests there could be a fault.

We're going to go through a relatively brief summary of the rock properties data base and some conclusions about the rock characterization in terms of thermal properties.

The data base measurements of intact rock properties on core samples, outcrop samples, and a variety which have been used as analogies, more or less.

We have on the order of 100 thermal conductivity tests; 300 thermal expansion tests; 75 mineralogical-petrological analyses, which have been done specifically for this purpose as opposed to the more general which have done a lot more than 75 mineralogical-petrological analyses. We have about 700 porosity-density measurements and 350 mechanical properties tests.

A real quick summary and again this is an area which I'm not an expert so I will summarize and if there are any questions, I will be able to point people to the right people.

The host rock matrix is in the Topopah Spring and what we're talking about now is relatively strong but the rock mass does appear to be fractured and we have based this on the vertical core that involves a correction factor as a result of the fact that the drillhole is vertical.

There is a rock quality to the Topopah Spring which is based on core diameter 2" by a double tube core barrel and the average rock quality is in the vicinity of 80%. That's based on a publication.

The implications of the data are basically that fracture-dominated excavation stability will be more of a concern than intact rock strength, which is not surprising.

The rock mass classification indicates rock bolts and wire mesh should be adequate for the exploratory shaft facility and the need for unheated repository drifts.

Following up on that, rock mass classifications that were imposed, we're working to develop a site-specific classification scheme to accommodate the thermal effects.

Insitu testing in G-tunnel suggests that excavation stability can be maintained during repository heating without extraordinary pressures during the year.

And this was put in--basically it's a page out of the Yucca Mountain Project Reference Information Base that contains some of the mechanical properties of intact rock and we're not going to go through them.

Primarily we're going to focus on the mineralogy of the site and we'll just talk about mineral abundance as a function of depth; geochemical data base; one cross-section of zeolite distribution and a summary which is mostly for information of zeolitized intervals.

The geochemical data base comes primarily in terms of mineralogy-petrology samples of the site and from similar analyses from core holes, from sidewall samples and holes that were drawn with rotary taken from drill cuts in those rotary and from outcrop all coming from the Yucca Mountain area.

We have as well some hydrochemical analyses from the saturated zones and very limited from unsaturated zones that Bill Wilson will talk about this afternoon.

We have done this considerable laboratory work on the stability of zeolites and other mineral phases as well as experiments on radionuclide and studies on sorption and precipitation of radionuclide.

Again we'll focus basically on the top here, the mineralogy of the site.

This is a diagram which shows all the minerals that were found in G-2. Primarily what it shows is that the rock is primarily composed of alkali, quartz, with some cristobalite and various minerals that are shown on this.

You can see here the distribution of the zeolite minerals which constitute the potential geochemical barriers in the Yucca Mountain area as well as being focused primarily within the Calico Hills area.

In other words, as I noted previously, to the west and south primarily the Calico Hills is actually still discovering significant amounts of glass. There is still glass near the bottom of Topopah Springs Tuff and in some of the upper units at Yucca Mountain.

Distribution of other minerals also show on this are various sorts of calcite which are increasing with depth down here. Indications of some alteration--

DR. LANGMUIR: One of the critical missing features of that diagram would be distributions and fractions. This is really the story of the matrix and if the flow was not in the matrix, it's irrelevant.

We really need to know the presence and their percentage in context with the fluid which you can't see.

DR. DOBSON: That is a specific focus on a lot of the investigators that are trying to characterize throughout the site.

We're going to look at one cross-section just to take a quick look at zeolite at Yucca Mountain. Again the cross-section is from the north-west to south-east in the middle and consists of the holes that are shown on this map.

There are a couple of aspects, the dotted areas here are the distributions of heavy zeolite alteration. One of the more most significant things is the zeolite does appear to be thinning out to the west and we don't have actual real data on this between the Solitario Canyon and the top of Yucca Mountain but the distribution of zeolite minerals over there may be very thin or in fact absent in some places, as we mentioned. In the south and western portion, the Calico Hills is glassy and not mineralized, not zeolite.

There are several points that we might want to make by this diagram. It may well be that the distribution of zeolite is related to past variations in the level of the water table but the present water table is shown on this diagram.

As you can see, the top of the zeolite is in the Calico Hills in the area of 50 meters or so. There are some in the Topopah Spring, in the base of the Topopah

Spring, above that but we don't have extensive zeolite alteration anywhere above it so that will be a significant finding.

One of the critical variables is, as Dr. Langmuir mentioned, within the distribution of zeolite regionally and what is there distribution specifically in fractures and how excessive would it be.

DR. CARTER: What about the variation?

DR. DOBSON: I'm not really an expert--

DR. BLANCHARD: That will be covered tomorrow.

DR. DOMENICO: That those zeolites will be or--

DR. DOBSON: I'm only briefly familiar with that. My understanding is that our current estimates are that the Calico Hills will not be--the zeolites within the Calico Hills--will be outside where zeolites might be altered; that the thermal envelope will be much nearer the horizon and the temperature is sufficiently low that they won't be subject to alteration.

DR. BLANCHARD: We have a talk tomorrow that goes into that.

DR. DOBSON: I don't want to read all of this to you but it's there in case anyone wants to peruse it. It's intervals for Yucca Mountain including G-1 and you can see all the zeolite intervals that have been noted and mapped at Yucca Mountain and some information about the characterization of the zeolites there including the relative percentages of cpt.

We're almost there. Now, to summarize our current thinking on the natural resources of Yucca Mountain--and had I known what view graphs I needed, I might have borrowed them all but I didn't so I brought one that we used last February and we'll talk about that in just a moment.

We're going to talk about the resource potential first. This is, as I mentioned, essentially modified, not very modified from one of the presentations, and we use it because at least I think it's a very good summary that you want to look for when you look for mineral goods.

It contains very relative information about the types of minerals found; dry chemicals, various structures and favorable types in ore deposits.

As was noted, the primary area targets in Southern Nevada today, although they will remain forever, are precious metals and specifically large tonnage gold deposits are the subject of much of the exploration that's on-going but Yucca Mountain does have potential for a variety of other minerals. There is certainly a little bit of silver and there may be other types of minerals that occur in the Southern Great Basin.

Again, as was noted, the host rocks that contain mineral deposits might be or may in fact include the rhyolitic volcanic rock such as found in Yucca Mountain.

A very important aspect, the hydrothermal alteration is almost without an exception an associate of mineralization at all of these places and including some of the deposits that have been noted such as the Bullfrog area extending over wide areas of ground. Due to hydrothermal alteration minerals such as ore deposits found in Nevada and elsewhere typically contain one or more of a group of tracer elements including arsenic, mercury, and various other ones are certainly possible and, of course, if you're looking for gold, you need to understand the distribution of all the minerals in the setting.

The presence of faults is one that one looks for where there is potential for mineral deposits as well as the presence of things like dikes and evidence of activity or a source of hydrothermal alteration that forms ore deposits.

This is a map of Southern Nevada or the Southern Great Basin near Yucca Mountain. It's very similar to the one Dr. Larson showed yesterday and it was done by a student of Dr. Larson's. The reason that I wanted to use it was to point out a couple of things about it.

As we noted, one of the significant things about ore deposits is the fact that Yucca Mountain is not hydrothermal altered. The rocks at Yucca Mountain except in the top 1,000 feet still contain glass in the volcanic units.

The Calico Hills and Topopah Spring show there is not significant evidence of hydrothermal alteration at the surface at Yucca Mountain and that, I think, is of interest.

We do, as Dr. Larson, have some indications at depths within some holes, for example G-2, which is several kilometers north of the repository boundary, that has relatively high hydrothermal interpretation by the investigators to reflect alteration of temperatures of up to 150 centigrades.

The data of that alteration has been estimated in 10,000,000 or 11,000,000 years so it seems fairly good evidence that that alteration probably was related to processes operating near but it's also important that the out-flow sheets at Yucca Mountain do not seem to be hydrothermal altered.

We need a considerable amount of data before we make any conclusions about the potentials and we intend to collect that data as part of the drilling program and that Jean will be talking about this afternoon.

DR. DOMENICO: Is the presence of minerals disqualified or just unfavorable?

DR. DOBSON: It's potentially adverse. It's not a disqualification.

One other note that I did want to make in terms of Yucca Mountain, we do agree that we need to characterize the potentials of the rocks.

On the other hand, as I mentioned earlier, beneath the paleozoic rocks are 10,000 feet of surface and though we definitely agree that we need to characterize the potential of that tuff, we don't think the first thing to do is to drill a 10,000 foot hole. We want to evaluate the mineralization and alteration. We need to get our physical data which can have mineral resource potential and we need to have this data before any decision is made in the future.

This is a short summary of some of the trace element data that was presented in a paper by Steve not to long ago for Yucca Mountain.

As you can see, it's not a very extensive data base. What dates we do have trace that the elements here that are presented in this map in general do not indicate any significant amount of mineralization. We don't have gold or silver and we think we need to collect that data.

Petroleum potential. I didn't realize, when I came, that I would get to work in the oil business. The two primary areas of petroleum data that we need is that the data that we have currently are sparse. There hasn't been a lot of exploration in the Yucca Mountain Region and; therefore, we don't have a very big data base in terms of stratigraphy such as would be ruined by petroleum companies or in terms of the data that you would collect.

DR. CARTER: Where is the nearest exploration?

DR. DOBSON: I'm glad you asked that question. I forgot to put

Yucca Mountain on this map. It's somewhere around here. This map shows the producing oil fields in Nevada. I think it's complete but we may have missed one or two.

The primary field in Nevada, the largest one, is in Railroad Valley which is more or less Central Nevada. It has several smaller fields in it. It contains a single well that's one of the largest in the United States so there is some potential up in Railroad Valley.

There are a whole host of models for petroleum potential in Nevada. Some of them relate to overthrust production that's occurring in Wyoming and the northern part of the Rocky Mountains.

Again, as we noted, there's not been a lot of activity around Yucca Mountain. The presence and significant amounts of hydrothermal alteration suggests that the potential would be relatively low but we don't have enough data to make any kind of conclusions.

DR. CARTER: Where would the exploration be closest to Yucca Mountain? As I recall, there was a well in the Las Vegas area and I don't know if it was done for publicity.

DR. DOBSON: I really don't know the answer of that. You can ask around if we have anybody that has that information.

DR. CARTER: It must be a matter of record somewhere. It has to be on the permit.

DR. DOBSON: I'm sure we can pull that data up somewhere.

DR. LANGMUIR: I wonder if you would comment on the suggestion that there's a large potential possibility at the site or can you find any fault with his reasoning?

DR. DOBSON: He's obviously a believer in the first model that I mentioned, that the rocks have tremendous potential as a source rock in the immediate vicinity of Yucca Mountain.

I believe his argument is that the rocks are divided in upper and lower. The upper plate rocks, from which we do have some data on the Test Site, are beyond the thermal window for petroleum potential. The lower plate rocks, we basically don't have any data on.

It was suggested through an article that we do have some data from the eastern part of the Test Site that may be thermal window but I'm not aware of the article so I can not comment on it.

This is a more detailed map of the Railroad Valley and it was put in for information in case anybody is interested.

The largest, I think, is the Grant Canyon field. It is the one that contains the largest well.

DR. CARTER: What kind of distance is this?

DR. DOBSON: I think 150 to 200 kilometers. Does that sound about right?

DR. WILLIAMS: How do you propose to understand the probable resources or do you--

DR. DOBSON: I think before we make any decisions on things like drilling wells at Yucca Mountain, I think we have to collect some data to try and determine if there's a part around Yucca Mountain that does have potential for that.

As Max mentioned yesterday, there is going to be some work done near

Yucca Mountain. Depending on the results of that--you know, if we have a combination of potential source rocks and structural information that indicates some potential, then you might go ahead with more work but as we mentioned, the potential source is likely to be very deep and a random program will not be a way to characterize it.

This is a brief summary of the oil production in the fields that were shown. This is a recent publication by Peterson of USGS of a petroleum resource evaluation of the Great Basin in Nevada and Utah that I believe concluded that was on the order of 300,000,000 barrels.

Next is a summary of key geologic questions that we felt needed to be resolved. We have talked about this several times.

We need to know the understanding of the regional setting of Yucca Mountain and we need to establish to the extent that we can, especially that it can effect the relationship between the regional structures and the faults at Yucca Mountain.

We need to understand the configuration of the high-angle surface faults at depth.

We need to understand the probability for renewed volcanism. You're going to get a presentation on that shortly.

We need to understand stratigraphic continuity of units--particularly in the distribution of properties with respect to water table.

We need to understand the effects of fractures both on stability for excavations and, of course, in terms of characterizing their influence on drilling.

We need to understand zeolite abundance along potential flow paths in the case of fracture flow.

Finally, we need to understand mineral potential and we're going to hear considerable more about these aspects throughout today and tomorrow and that's all for me.

DR. LANGMUIR: I presume that all of these items are among the 106 studies that are being discussed?

DR. DOBSON: You bet.

DR. BLANCHARD: If there are no other questions, we will have a break at 10:30 and 10:40 we'll be back.

(Whereupon, after a short recess the Board reconvened.)

DR. BLANCHARD: I'd like to introduce Bruce Crowe and his talk about volcanism in the vicinity of Yucca Mountain.

DR. CROWE: I'm Bruce Crowe and I'll be talking about volcanism in the vicinity of Yucca Mountain and the approach for assessing the potential for volcanic hazards.

We have to evaluate the hazards of future volcanic activity with respect to disposal of high-level radioactive waste at Yucca Mountain.

What I'll be talking about for the presentation; I'll give you a brief overview of the geologic studies we've been doing starting since late 1979 and I'll summarize the progress that we've made in those studies and I'll talk a bit about how we use the data of the geologic studies; how we have used these to formulate probability and consequence analysis and I'll emphasize a bit on the ongoing activities that we plan to do that are described in the characterization plan.

I'll talk about the aeromagnetic anomaly sites mostly tomorrow.

Then I'll present what we think are two scenarios for future volcanic activity and summarize what our view of the volcanism issue is.

First of all, there are two aspects of the volcanism issue. There's the possibility of silicic volcanism at Yucca Mountain, and, as you look at the satellite, I'll show that in just a second and so one concern we had in the program is silicic volcanism and; second, is basaltic volcanism.

In late 1979, early 1980, we looked at the silicic issue, and one thing that was brought up is this volcanic issue, a critical issue, and what we pointed out was that the youngest activity in the region is from the Black Mountain Caldera, which is from the Stonewall Mountain Volcanic Center, which is further northwest.

Basically, here is Yucca Mountain perched on the out-flow up top. Yucca Mountain is off to the side northwest.

The basic conclusion of this is we don't think it's a problem. Volcanism studies pretty well suggest the possibility of further volcanic activity small.

There is one remaining concern that we're looking at and we'll talk about that tomorrow.

One possibility for a couple of the anomalies is there could be some kind of--we did drill one of them and there's a second one that needs to be drilled. We need to put this totally to Bill, the potential for volcanic hazards.

Now, what we focused is basaltic volcanism and I won't go into details. You've heard quite a lot on this already.

There are seven quaternary centers within 8 to 47 kilometers and there are strombolian basaltic centers with small volume, scoria cones, and aa flows.

We have been studying this and the emphasis on the early part of the study that we're looking at does represent a major problem for the Yucca Mountain Site.

Now, when we first started the study, we did some thinking about basically how do you gather information to really assess a problem of this sort and the traditional way that was approached was simply to make judgements about; is this risk small or large or whatever, and we felt we wanted to try and go beyond simply a mental judgment decision of; is volcanism a hazard, so what we did is a two fold approach.

First of all, we viewed the standard geologic studies that are needed. Basically the geologic mapping, geochronology, geochemistry, and geophysics to evaluate volcanism.

We did the regional and local perspective and then we did them on the Yucca Mountain Region which ranged from 12 Ma to holocene.

We published these results that are available in mostly the time frame 1980-1986.

Going beyond that data, we did a geologic study used for risk assessment where risk is defined as some kind of probability and consequence analysis.

What I want to talk about a little bit is what is the geologic background in regards to these probability assessments.

This is the final slide that Jean Smith for the State showed yesterday where he described this as our progression of volcanism from 35,000,000 years to the present. This includes rocks 6,000,000 years old.

The two significant points here is that there was a transition in the style of rock so we see it switched to where in the post 10,000,000 year rocks had been almost entirely basaltic in the Southern Greater Basin.

You see all sites of activity concentrated on the outer portion basically but what's intriguing is this zone that you see here that appears to be a zone where volcanism has continued while areas on the adjoining side have declined in volcanism and that's where we have the Death Valley Pancake Zone.

The Death Valley Pancake Zone, I'd like to be cautious with this--and I call it a volcanic zone, and I use that basically after Smith published a few years back where they define zones just on the distribution of rock so I basically drew a line around this area, the Death Valley Pancake Zone.

Many people call it a belt. I'm not sure that it is but we formulated this as a zone.

Now, in detail when you look at the Death Valley Pancake Zone, there are three segments to this zone which gaps between the Rifle Range and into the Test Site and across the Amargosa Valley into Death Valley.

Quite a few people believe that the Death Valley Zone probably belongs in the Western Rift Zone and you end up with two spots.

It's very easy to disagree about whether or not a structure is significant or not but that is what the debate is about.

I personally feel that what we are seeing which we know has occurred in the whole Great Basin and whenever you have structural that are probably Walker in control, you're leaking basalts along those zones.

We have found that there is no significant patterns as to how it moves and Lunar Crater, there is a fair amount of data that volcanism has moved not necessarily systematic but progressively south to the north with the youngest occurring up here and the age of the volcanic rock ranging from 2 to 3 on the south part and down to 4 and 5.

Now, what we see in the Test Site is very different. We divided the rocks in three categories.

Silicic episode, this is a fairly large range of volcanic rocks associated with the Timber area complex.

We've encountered some basalts and drillholes under Crater Flat. We see them exposed at the surface and basically what we see is the types of basalts. They are large, which is a characterization of Shield-type volcanic rocks and they are especially associated with the cold-air complex.

About 9,000,000 years ago we saw a drastic shift of volcanism. What we see now is an interval between 9,000,000 and 6,500,000 years that all basalts occur in the northeast side of the structure extending into where there is a movement it's been proposed of Walker Lane.

What you see is all the basalts of 8,500,000 to 6,500,000 years all occur to the northeast side of that structure. There are two little basalts here and they get less in this big thick line.

Now, you see a hiatus in volcanic activity to 3.7 and we're fairly confident that a accurate figure. The area has been extensively mapped, extensively drilled and we have not encountered any rocks between 3.7 and 6.5.

The next period of volcanism, everything shifts to the southwest side and there has been a surge to the west and we think it's due to Walker and there are about four or five sites of activity.

There's a Buckboard Mesa. There is the alignment of 1.2 and what we call the Sleeping Basalt at about 300,00 and there's a Basalt Center over there.

I want to put this on to remind you of two things. There is a drastic change of the volume of material. These are of silicic episode, and then there's this age group, and then a recurrence of what we call the younger Walker Lane Belt of volcanic activity in that younger group of basalts.

You've seen this slide quite a few times and I think we will talk about it tomorrow out in the field so I won't go into any great details.

These are the three major sites in Craterflat that I talked about.

This is a view of Black Cone and I simply put it to show you what a typical form of basalt looks like.

DR. WILLIAMS: What's the estimated age?

DR. CROWE: One point one million. It's probably an approximate age.

This is 9,000,000 years on Pahute Ridge. I put it on here so you can see the route it took for this kind of basalt.

There is a second Cone Center here and these are future dikes that fed the basalts. We think about a quarter depth that the structure of feeding basalts is going to be these future type dikes like this with dimensions of possibly five meters in width.

Now, I want to talk a little about how we've taken and tried to formulate an approach to try and grasp the magnitude of the problem which is a conditional probability where first you have to get a volcanic event; and second, the condition of the probability is that it intersects with a repository because in order to have direct effects on containment of waste--

Before getting into that, we must discuss the formulated probability. No volcanic event before time; the rate of volcanic event and the probability an event is disruptive.

Now, the two things we work at to get data is most importantly the rate parameters.

When we did the original publication, we did two techniques. We looked at the number of cones where we looked at the hole, frequency of the cones, and treated each event and we divided them in accordance with the age of the activities to get a simplistic rate.

It's not a very eloquent approach to the program. We focus our studies in trying to get at the basic magma eruption rate, the process of magma eruption rate in the zone you're working with and we've been looking at the rate characterizations for volcanic fields and we will advise the centers.

The second parameter is a disruption parameter which we define as a ratio of the area of the volcanic disruption zone or the area of a repository.

That's on the size of the volcanic feature. If you have a large magma chamber, that size would be larger than the dimensions of the repository so that would control your "a" and the ratio because we are dealing with basalt dikes that are fed with very narrow dikes. Basalt centers are fed by narrow dikes and the other thing is the area of the calculation.

Again, the volcanic disruption zone for the Yucca Mountain Site, the area of the repository, we drew a line of 25 kilometers around the center and we use that at the area.

There was a bit of arbitrariness and that area turns out it's fairly significant. You can jump 50 kilometers, 100 kilometers, and move around in your numbers so we tried to find another way to attack that area.

What we chose to do is look at the geographic distribution of volcanic centers and we brought a computer program that fit the minimum area circle and minimum area ellipse.

What we did, using a variety of ways, and the minimum area ellipse, we basically looked at the whole range of values using the multiple areas and calculations and then we defined the probability bounds by the minimum and maximum values out of the probability table.

Since our 1982 calculations, we've come up with some new chronological assumptions and recognizing that some of the events that we thought were older can be significantly younger and I'm going to talk about that in a moment.

I want to briefly address the changes in the probability range. On what I found, we can jump down to the 10.7 range.

Now, I don't want to refine those numbers until we get more data on the chronological events and we're going to drill-- whether they're basalts--and we will learn where they fill in to the sequence.

What we're doing right now is looking at our magma eruption rate to go to a more precise way of looking at rates.

Here's a little bit of the chronological since this has been an important topic in the last few years.

When we originally did our data, we did what every geologist did, we went over and sampled the lavas and we looked at these volcanisms as basically a single event and assumed that the date of the lava flow was a good representation.

This was a standard assumption for years and years and based on that, we came up with a number of 200,000 years at Lathrop Wells.

First of all, we did see a lot of variations. There was a study where they submitted samples from the Lathrop Wells to test the chronology. They got from negative ages to over 700,000 years.

What we decided, we've got a source of variability that should be determined. The morphology is inconsistent with the 200,000 years by the fact that a sample was dated 230,000 years ago.

About two years ago we got in contact with a group of people working mostly with John Dorwin. He had been doing some very detailed geomorphologic analysis in the field and we asked him to come up to the cone and his conclusion was that it looked much younger than the date of 270,000 years and the lava flow.

I want to show you real quickly the kinds of problems I'm fighting because I don't think we're conveying any information on these dates.

What we did, we asked Burkley Center to date these. I sampled them with them. We ran each in triplicate.

All I want to point out here is, first of all, our ages ran from as young as 37,000 years to as old as 575,000 years as precisely as possible, and; secondly, there were different amounts of radiogenics, which should be the same.

He uses various techniques and he came up at 130,000 years for these centers.

My feeling is that I would wait to take this date and convince--

DR. LANGMUIR: We're also seeing that there is some problem in the system that's giving us some old ages for the younger rocks.

DR. CROWE: What we've done is kind of assembled a group to look at the chronology of the Lathrop Wells Volcanic Center and the center in the Yucca

Mountain Region and we've had to focus on detail studies to try and arrive at the chronology.

We'll decide this in two ways. First, the date technique. We did a survey about a year and a half ago. We asked what would be the first appropriate way to attacking this problem of determining chronology of 20,000 to 30,000 years up to 300,000 years and we looked and we agreed that these two had the most potential to give us the potential for good numbers.

The first is a disequilibrium technique. When you have a magma event, and they come out of the sector and you can pressurize a cone in the scope of the cone, various times it goes back to the disequilibrium and you can date the time.

The problem with this technique is that it hasn't been done by standards and you need a lot of material to count on and we don't have it in the basalts but that we're pioneering in Los Alamos. It has been possibly funded by the Weapons Program and they're the best at measuring the smallest isotopes. Mike Wallace, he's working on developing that right now.

The major problem is isolation of thorium. We think we're ready to start measuring rocks. He has gotten thorium where count statistics look quite good to give his resolution in a 10,000 year time scale and we gave him his first rocks to try this technique on actual basalt samples.

He thinks by this summer, if the machine behaves itself, we'll have the first numbers out.

The second technique--and what we felt when we approached the dating was this is a controversial topic. We wanted and tried to get another consistency. We were quite enthralled by the He3, and that rate has been both worked out and calibrated and actually this technique was used in Hawaii where the results were used to carbon. Part of the technique is basically Carbon 14. It depends on latitude and formation.

We're going to use two approaches. Calibration would be one. We're going to try to calibrate basalts in the region, calibrate our He3, He4 to those basalts.

The problem is we're depending on K-Ar for our dates but we're arguing about the--basically appeals of this approach is that that is very easily done by conventional gas and we're working at Los Alamos. The machine is assembled, running, and their actually running the first mineral in the 3-4 technique.

With the 3-4 technique, we'll get the best sample in the field. I don't know much about it. It looks like it may be suitable.

Steve Forman, from the University of Colorado, should be able to give us some good numbers and the age reasoning of less than 10,000 to 100,000 years.

We also will be using rock variation techniques but not to date. There are other techniques that we're using with the people identified and I'll talk about how we work them in the program.

I'm running out of time here and so let me just quickly tell you; you have to be very careful in calibrating in an air environment which we have at Lathrop Wells, and we've been putting a number of 15,000 years based on the analogy recognizing that that's probably a lower limit number. We don't have anything firm.

We have two other dates for Lathrop Wells. One is a--there is a Carbon 14 on 19,000 years and we think that makes sense from the cone morphology but we don't regard that Carbon 14 as a definite date. It's a new technique and we're not sure. The morphology has not been worked out.

Fred Phillips has done a number of cones and he has an approximate number of about 50,000 years he thinks for the cones.

We're still in the process of nailing down this age. It can be as young as 15,000 years or slightly younger.

Let me just show you a few examples. What we're finding is they actually form multiple eruptions of very short durations but a short period of inactivity.

The northern part of Lathrop Wells, there is no cone apron here and the cone slopes are completely intersecting. You notice this little window that we see here, and this is regular cone material, this is an older eruption where you had a short eruption and then a fairly long length of erosion and a second eruption came on top of this.

What we're finding is they're all showing that same thing and I have to caution you on how you use this. Duration of activity for the duration of the whole activity versus individual events. We think each individual event is based on just what we know about rates.

The cones would be equivalents based on days or a month maximum. On these things, that's allowing to show multiple eruptions.

DR. ALLEN: We can't say just yet but are we talking about a few thousand years or --

DR. CROWE: We may even be approaching 100,000 years of activity. My problem is until we get this dated, we can't say that with certainty.

This is the other end of the time gap here and here's an older sequence.

There must have been a time interval in order to burrow these lava surfaces.

These have never been seen before in the study of these kind of basalts. This is what we think a 200,000 year cone looks like. Look at the cone apron and notice the cone itself.

Next slide. Let's see where I'm at. Our current status of the chronological study is we defined two centers where the last eruptions took place and I emphasize the last eruption. The center is not young but there have been multiple eruptions that could be approaching the 10,000 year time frame.

That's the Lathrop Wells Volcanic Center and the Hidden Cone Volcanic Center.

What we're seeing is they're polycyclic. They're formed by multiple eruptive events and shorter periods of activity with longer periods of inactivity and we think we see an eruptive sequence to these in larger volume, initial eruptions, as well as a decrease in volume; decrease in ratio lava/scoria, and final eruptions, scoria only.

So what we're doing right now, we're concentrating on eruptive patterns and making a basis for future predictions as well as magma rate calculations and to try to revise them and make them as precise as possible.

We're trying to focus on our ability to date the rocks in this time zone.

I'm going to have to go very quickly just to give you a feel of how we approach these things.

The reason we like rate characterizations, we think we can place the volcanic activity to a process foundation rather than just trying to date it. We want to try to approximate and control it.

What we noted on the other slide, and what I published in 1982, you see a decline in magma activity. I think it's .8 and the slope of that line gives us the magma eruption rate.

I also separated the events of Lathrop Wells and what I tried with the approximate age we found, we got no age in that slope. The slope was 210 meters per year and the calculation came up to 205 and those are virtually identical numbers.

Now, what we started thinking about is what could be controlling that or are we not sensitive to understanding the process or are we on to something as to how volcanoes behave and we looked at data from Hawaii and large centers and this is a work sheet from Shaw and published in 1987.

There is a controlling rate and for Kilauea, that rate is a tenth of a cubic meter per year and the significance here is what it means if you study carefully enough, you can define magma eruption rates.

Now, the big question is, can we make the same argument--and we can argue it appears that you can do this if you do two things.

You have to get the chronology of your centers with the volcanic type relationship very well worked out and you have to use your own chronological studies.

What you see on the volume curve for this year is two things; that we have a nice curve for it, and the curve flattens, which is consistent with a weaning system and basically what we plan to do is refine this curve and we intend to use them for our probability characterizations.

Let me show you this equation that we use and the time sensitivity of it.

The time of the next eruption is defined by a representative eruption volume, by a magma eruption rate, and the time of the last eruption.

By using a whole range of rates, I can come up with ranges from 1.8

thousand to 360,000.

Now, to start to get into the summary here, I would like to proceed to the revised volcanic scenarios.

The original scenario has rising basaltic magma, fed through narrow dikes, directly intersects the repository; magma carries the waste to the surface and forms a short-duration, strombolian eruption.

The new concepts are long-lived, polycyclic volcanic centers with decreasing eruptive volumes and decreasing ratio of lava/scoria through eruption cycles.

That would lead to two scenarios for future volcanic activity in the Yucca Mountain Region.

Basically the geologic record for future activity of recurrence of a small volume eruption at the Lathrop Wells or Hidden Cone Volcanic Centers involves scoria eruption; surface effects confined to cone and immediate surrounding area. Recurrence times may be less than 10,000 years.

If I take the volumes of them, using my rate curves, that would be less than 10,000 years and so this would be our expected rate in the Yucca Mountain Region.

Now, we're looking at consequences of these. There are virtually none unless you were standing so close to the cone without backing up a little. Basically you could be that close.

Now, the only way we can see effects is we have a couple processes for seismicity and ground water effects. Seismicity, you'll get events like 200-300 a day to 2 or 3 earthquakes. That's well below the norm.

The other question is whether the surface-ground water is effected and when you look at these, you do see this is ground water. Now, to determine the ground breaks and what kind of fault systems are there, we'll get the data on that.

I want to make two points. These things are fed by narrow dikes and when we look at these in the field, we see very little definition but more important is the distance. The Lathrop Wells Site is 20 kilometers away and it's down-graded to Yucca Mountain.

So, in the second event, that we think is a possibility would be the same kind of event that we talked about before.

Now, formation of a new volcanic center that disrupts Yucca Mountain, a larger volume initial eruptive event, 50,000 to 100,000, and if I put them into the minimum and maximum, I would get numbers from 1.8 to -8 range.

Now, as far as consequences dependent on these scenarios would be eruption mechanism, strombolian, hydrovolcanic, geometry of waste-magma interaction, and mechanisms of incorporation of waste .

You can devise a whole range of scenarios. You can come up with a whole range of things. We're trying to decide how to handle this.

Our best guess would be to do some kind of an analysis of the range and of potential effects. We're not quite sure how to handle this.

All of the centers are closer to the northern side and may well have a fault and I did some very simple calculation. I went to get a feel how nature dispersed itself. I did a calculation best fit to the current conditions at Yucca Mountain and those lines outside of the Yucca Mountain--geology never gives you perfect data.

We did not use that kind of approach in the probability. It appears that this structure has remarkably focused all activity. All activities are very closely clustered along that line.

Now, let me summarize the volcanism issue by the two sides.

First of all, we have recognized that volcanism is an issue from day one to this program. It's based on the fact that we see five centers in the Yucca Mountain areas so volcanism is a common process in the quaternary.

The last eruption could be at least late pleistocene or holocene.

We have to recognize that there is a dredge of uncertainty. Many techniques are new. There is always going to be some uncertainty. There would be some variations until we get our chronology more established and clearly there is a strong public perception of volcanism as a dangerous thing.

The public has been bombarded by t.v. shows, volcanoes blowing up and sending out fire balls and when you mention volcanism, that's the image that it connotates.

On the positive side, the risk of future volcanism is low. Particularly a consistency of geologic record and within the last 8,000,000 years we've erupted at scattered locations throughout the Test Site.

We see no signs that volcanic rates are increasing. There seems to be some data that they're decreasing.

There are no significant changes in basalt compositions.

We do see some time/space patterns suggesting a decrease in volcanic rates in the southwest migration; decreasing volume; some geochemical patterns; and we propose to study recent volcanism along the Owens Valley Province.

The most likely volcanic event is a small volume eruption at the youngest centers which has no effect on Yucca Mountain. Scoria eruptions are common at polycyclic centers.

Finally, the low probability of a volcanic event intersecting Yucca Mountain gives us some confidence that the risk is low.

I think I'll stop there and open it to questions.

DR. CORDING: Did the 1982 calculations, ere those based on a minimum area ellipse?

DR. CROWE: Yes, they were. We had some published in 1980.

DR. BLANCHARD: If there are no more questions, I'd like to move on to seismicity.

DR. KING: As Max said, my name is Jerry King and it is certainly my pleasure to look forward to addressing the Review Board and telling everyone about the seismic hazards in the vicinity of Yucca Mountain and an approach for assessing the potential hazards.

I'm not going so much into details of the site investigations. That will be covered by Jean later this afternoon and in some of the presentations tomorrow.

The topics I'm going to cover include earthquake ground motion, which is an issue both in the preclosure issue, to round it off to 100 years, and for 10,000 years postclosure.

Underground nuclear explosion ground motion, obviously just a preclosure.

Surface faulting, which has been identified as an issue because of the potential for ground eruption beneath, which would be proposed to be located in Midway Valley, which I'll point out to you in a later visual.

Underground faulting, which is an issue in preclosure and it might impact the requirement for retrievability and during the postclosure period obviously the concern is for the potential for a fault to actually intersect and approach waste paths.

Finally, I'll be spending a fair amount of time on effects on ground water.

You've already heard that the seismicity in Southern Nevada is fairly low. On a continental perspective, it's greater than would be characterized east-central United States. Certainly considerably less than the active margin of the San Andreas Fault.

There are several major sizable belts in the western United States. There has been seismicity in the east-west which shows up better on the next view.

The largest earthquake was in 1873 and another earthquake with a magnitude of 7.2 in 1932. It lies within this Walker Lane zone, which Dave Dobson has talked about earlier, and being investigated for potential occurrence of that type of earthquake at the site.

In 1978 the the U. S. Geological Survey Seismographic Network-- I believe there are 53 stations in total including a ring of half a dozen stations right around Yucca Mountain. This zone is a zone of potential induced seismicity from the underground nuclear explosions which, you know, occur on the Nevada Test Site, which is adjacent to Yucca Mountain.

There are some zones, some hot spots of activity, which correlate poorly with geology. This east-northeast trending zone, which correlates with Rock Valley

Fault, it doesn't correlate with anything, and some of the higher level of seismicity here and here is probably partially due to the effects of the underground testing but there are certainly still some in there and part of our job in the next few years is doing a better job in separating out the induced seismicity for the purpose of natural seismic activity.

These focal mechanism beach ball diagrams indicate the variety of focal mechanisms, both strike-slip and normal, and this has to be accounted for in our Department; which, as Dave Thompson has talked about, is about the surface geological extension, and then as evidenced by the north trending range fronts.

We certainly do see the normal components in a number of these mechanisms but there is also the strike-slip and there's probably a half a dozen more competing models as for how this is producing this type of defamation and these models will be investigated.

Probably we will never be able to say exactly what is correct and we will investigate them to the extent that we have to for the various models and to assure ourselves that our design basis accommodates the hazards implied by any credible model.

DR. ALLEN: Is it consistent throughout the region?

DR. KING: Yes. Tension access, for the most part, is in the northeast trend.

The general area is undergoing active tectonic defamation.

These are pliocene faults and the closest one to Yucca Mountain is in the Bare Mountain Fault which shows up over here. This is the most active fault in the whole vicinity of Yucca Mountain.

In addition, there are a number of north trending high angle normal faults which Dave Dobson showed you in a cross-section.

This sort of turtle-shaped outline is the boundary.

Midway Valley is here where surface facilities would be sited.

DR. ALLEN: Do we know that the Bare Mountain Fault is more active at this time?

DR. KING: Yes. There is a lot of evidence of faulting on the Bare Mountain Fault.

I don't have the numbers in my head but slip rates are considerably greater than the local faults.

It's far enough away, though, that due to the ground motion--it doesn't seem to but the most probable source at the site based on what we know would be at Bare Mountain Fault. It's based on our current approach.

Just a word about some design considerations before I go into the approaches that we've developed but it is important to keep in mind what it is we're designing it for.

With respect to the preclosure, which present the most concern, the requirements are very thick sheer concrete, sheer wall construction. The sheer walls are five feet thick, I believe, and the result of that is even without a seismic design built into these facilities, they would appear to be very resistant to potential earthquake, ground motion. That appears to be the case of strong ground motion.

During any randomly picked 100 year period seems to be quite slow and particularly of the order of 10,000 to 100,000, less then we expected cost associated with a seismic induced accident, and this is a result by a preliminary study.

Our approach to dealing or characterizing the site with respect to ground motion hazards is, first, to investigate the local and regional faults.

You'll be hearing a lot more about this from Jean later today and the presentations in the field.

I won't go into this in any detail but, suffice it to say, it involves a large amount of investigations including geological mapping, geological studies, tectonic interpretation.

All the tools in the geologist's tool kit are going to be applied to investigate the seismic hazards at the site.

As I said, one of the objectives with the tectonic models is to define what the hazards might be.

Particular studies for ground motion is to characterize ground effects and can quite strongly effect ground motion by earthquake and we have to investigate what those local side effects might be in Midway Valley.

Also some studies have shown that there appears to be a fairly strong local path which effects the impact, the amplitude of ground motion but underground nuclear explosions, which is a fairly strong shock at the site, they seem to get fairly large differences in the amplitude.

We'll be continuing those studies to characterize the problem with ground motion hazards, which are models given the earthquake magnitude, and in a while all of this information is going to be utilized to estimate the probability of the ground motion level at the site.

We will determine the 10,000 year cumulative-slip approach, which I'll explain in a minute. I believe you heard something about this yesterday so I'll spend a little bit of time on it.

The 10,000 year cumulative-slip earthquake, which I'll call the CSE, is a deterministic approach for developing an appropriate design basis. It's important it have said what it is now and what it isn't.

It's not an approach to predict what the expected earthquake is at Yucca Mountain; what the maximum earthquake is; what is the characteristic of the earthquake or what the most probable source of strong ground motion is.

It's, to some extent, to develop an appropriate design basis considering the seismic setting, then the nature of the setting that it was designed for.

It has been crafted and is expected to produce a design basis with exceedance probability in range 10-3 to 10-4 and this range has been chosen, in the most part, because it has been found that this range is near the seismic design basis of a particular nuclear power plant in the United States and considering the facilities, would certainly appear a much lower risk than an operating power plant.

It is our feeling that if we do succeed in getting this range for a design basis, that it would be very conservative.

As was pointed out, there seems to be a bone of contention about CSE but I think it's mostly a misunderstanding of what the CSE has intended to accomplish. It doesn't adequately rid the hazards of the seismic setting at Yucca Mountain.

This can be illustrated by a hypothetical fault that produces a magnitude of 7 earthquakes every 100 years versus a high magnitude every 100,000 years.

Obviously the hazards are quite different.

DR. ALLEN: This setting, is it true for any other geological setting?

DR. KING: Well, yes. It's one dimension.

DR. ALLEN: It's not unique at Yucca Mountain?

DR. KING: It turns out it is more appropriate for more active areas of the west for nuclear power plants. It wouldn't work for a nuclear power plant at Yucca Mountain either.

Finally, part of the definition of the approach, is that once we go through it, there would be a probabilistic seismic hazard analysis that was in the desired range, and, if not, we would go back and modify the approach.

DR. ALLEN: For each fault in the area?

DR. KING: That 's correct. We will do that for each fault that could potentially be a significant estimate of what the ground motion would be as a function of frequency and look to see which faults and with what frequency; and, based on judgment at this point, it appears that the following approach would control ground motion in the entire frequency of interest at the site but that's just a expectation that has to be borne out by the actual studies.

Now, it would take into account the length of the fault and the expected depth of the fault.

You look at how that slip might be released. It might be some mechanical interrelation. It's not a trivial problem to get to that magnitude even once you have released the slip. It presents less problems then estimating a maximum.

As I said, we based this on current standards. This is very preliminary. Controlling this event in this approach would appear to be on Paintbrush Canyon.

The median peak ground acceleration would be 0.5 - 0.6 range. This is higher than the current .4.

In effect, we're proposing a modest increase in the design basis from what we have now.

We have looked at the potential ground motion for nuclear ground explosions, taking the worst case of a 700 kiloton shot at the closest point of approach to the repository, which could support such an explosion at the Buckboard Mesa area.

The ground motion would still be on the order of ten times smaller than what we would expect from the earthquake so it sort of appears that ground motion from underground nuclear explosions are not going to control the seismic design but we are going to refine our continuing relationship and to actually confirm that that is the case.

DR. CARTER: What kind of ground motion do you get from the maximum reliable testing now at Yucca Mountain?

DR. KING: I can't tell you the number off the top of my head. It's certainly much much less than even the worst case, because, number one, current national policy is to limit to 150 and we assume 700 and the testing is ongoing so rather than Buckboard Mesa, which is much closer than the site, it would be less than 100 I'm positive. Very very small.

Per data on the Test Site shows that the underground workings are extremely busy with--they've recorded 25 or 50g so as far as my workings, it doesn't seem an incredible threat.

We have a couple of very preliminary seismic rates of the site and this was done a few years ago by a few varied associates.

I just want to show it to illustrate a couple of things. In a problematic analysis, the Paintbrush Canyon dominates as well as the cumulative approach. This shows this is being contributed by Midway Fault, and it's not known that it is active.

At the point 5 to .6 range, Paintbrush Canyon is about 10 or -4 and less and total hazard would be about double this. This is from Paintbrush so based on very preliminary analysis, it would look like your approach would get us in the designed range, which is one of the reasons we came up with it in the first place.

Moving on to faulting hazards--

DR. ALLEN: If I understand this correctly, your CSE, that approach would not be acceptable for a nuclear power plant at the same site?

DR. KING: Well, you would--it does not apply. For what it's worth, it would be extremely difficult to apply at Yucca Mountain for a nuclear power plant.

The faulting hazard, the concern is for potential for surface faulting beneath surface waste-handling facility.

Engineer's tell us they certainly have the capability to design to withstand offsets.

Our preferred design approach is to locate them; make them aware the potential of faulting is very low, which would undoubtedly be controversial.

For the purpose of copying the site characterization program, we've identified a goal which is to demonstrate the probability of 5 cm offset beneath surface waste-handling buildings is 10-4/year.

This is not an accepted criteria for the site. Just because we meet it, doesn't mean the site is okay. It's a goal we've given the program to accomplish to see whether or not this goal is met.

To put some numbers on this, on the probability we site local and regional faulting patterns, densities, and potential mechanistic inter-relationships between the local faults.

In particular, the probability of some faulting on the Paintbrush Fault, that's a probability. If there would be a second fault, how big would it be, what's the probability of that, and a key to determine this probability is to trench Midway out.

In the same report, which was a seismic design for a surface-based facility, we looked at faulting hazards as well as ground motion hazards and we estimate faulting hazard in Midway and about a half a dozen approaches and I won't go into what those approaches are now but you can see that for probability associated 5 centimeters offset 10-4 per year.

It's important to point out that this result assumes that the trenching program has a negative result. If that turns out to be the case, then we can take credit for that trenching program and reduce the probabilities of faulting that you would get at a random point if you didn't go in there and the detailing trenching program.

This is Midway Valley. Here's the Paintbrush Canyon Fault. Here is where the facilities would be located.

The proposal is to have a trench that goes across this whole area and one perpendicular and smaller trenches at these here locations.

These have not been finalized. That is part of a study to find out the trench locations and they will be based on pressure lines to locate them.

Faulting hazards, postclosure, the concern is potential for faulting in areas of emplaced waste.

The site characterization goal is to demonstrate that the probability of 5 cm on any fault or displacement is 10.4 per year.

As you will hear about, we have an extensive underground program. I think you already heard about this. It will be drifting over to investigate some of the major faults and whatever other faults that are found in the repository. It is very difficult to detect and date faults underground.

Faults with slip rates large enough to jeopardize goal should have surface expressions. These will be faults on the order of Paintbrush so it's not likely we're going to have a real surprise but with detail surface mapping and the probability estimates that will be based on the surface mapping and surface studies looking at the regional analysis--

Well, that's enough on that. I want to make a point, first of all, to remind you that one of the reasons the Yucca Mountain site appears to be favorable--and one of it's most favorable aspects is that the site is a considerable distance above ground level and a considerable distance below the ground surface at the same time.

It is this layer of expansive rock between the disturbed zone which provides the primary barrier which can provide for waste isolation so we're interested in potential disturbance of this ground water system and the ground water table itself or other mechanisms that water might get into the repository.

As Bill Wilson will be telling you after lunch, the current preferred model for a ground water system at Yucca Mountain and for the Southern Great Basin is controlled principally by stratigraphic and structural features of the site. It is driven primarily by gravity and a consequence is that the ground water system is not connected with the tectonic process.

It would appear that changes in position of the water table would be fairly modest under such a scenario under such a preferred model for the ground water system.

There are ways that faulting might disrupt the ground water system at Yucca Mountain. We can imagine the fault start performing and essentially intersecting the path of run-off water causing a change in the surface infiltration pattern which might concentrate moisture where it hadn't been before.

That faulting might create barriers to lateral underground flow and the faulting might form a conduit to an underground flow, which might tend to concentrate, and these scenarios will be looked into, but I don't think under this model that the potential for disruption is very large.

The program has identified an alternative model to the conventional model, which is the preferred model for the ground water system, which holds back the hydraulic and effective thermal conductivity, and are controlled mainly by in situ stress fields and have to undergo significant cyclic changes over periods of tens of thousands of years.

Now, the base of a ground-water system is an upward-flux boundary for heat and fluid and is sensitive to tectonic stimulations.

Now, the mechanism which controls the conductivity is--namely, the model holes that near the end of a tectonic activity, an earthquake cycle fractures or holds, open by an extension of stress, and that results in the ground water being held down.

This can be explained by Jerry, who explained it to me. It's like the leaking swimming pool. You have cracks in the wall of the swimming pool and you're pumping water in the swimming pool but the water can't rise because it's running out the cracks in the side of the pool.

Now, you have the cracks close through the release of tectonic stress due to a large earthquake. The crack can close and the water can continue to rise up because the conductive has been dramatically decreased.

A part of this model is the pump of the swimming pool, which is essentially saying that the boundary of the ground water simply is an upward-flux boundary for heat and fluid and is sensitive to tectonic stimulations.

Under this tectonic model a large rise in the water table is conceivable and obviously the Department intends to continue to investigate this model.

Fortunately, this model is testable. It makes a number of predictions including that the chemistry of water should be different than water from source.

The idea being that this cycle has occurred which has been elevated in the past and there should be underground water from past tectonic cycles and they're chemistry should be different from the chemistry of--the model predicts that the normal components of stress should be slow at the end of the tectonic cycle.

DR. LANGMUIR: For quite different reasons.

DR. KING: That is quite possible.

One of the key predictions of the model is that some of the calcite, which you will see tomorrow, which is fairly widespread on the mountain, the model can strongly predict the age and organics of these deposits.

Assessing the potential for ground water system requires some consideration of novel and innovative interpretations of tectonic hydrologic processes.

The conventional model for the Southern Great Basin--and the model is the currently preferred model--is being challenged.

Resolutions will depend on additional data collected during site characterizations.

Extensive cross disciplinary interactions and analyses within the DOE program are needed.

I think it's important to point out that for this aspect of the site investigation program, as well as all the other aspects, it is a plan. It is a starting point for investigations.

The intent is to modify this plan as to what we get out of the characterization, depending on what data we get, and there may be some necessity to refocus this whole program to more or less address the predictions and, at this point, I'll stop and entertain any questions. Thank you.

DR. LANGMUIR: If you're looking at a swimming pool with cracks at the top and you're trying to find evidence somewhere else, you should be able to find this evidence in other locations.

DR. KING: That's actually correct.

DR. LANGMUIR: I think that's more relevant rather than to suggest that the zone is related in some way to chemical. It's to be effected by reactions that occur as water and not have a history that reflects saturated zone occurrence at a higher elevation.

DR. KING: Your absolutely right. It wouldn't be associated with the system at Yucca Mountain.

DR. DOMENICO: If your rate of defamation is slower than your distribution time, you have a defamation of a constant pressure and that's what's happening out there.

When you have an earthquake, which is a rapid flow, the rate is fast with respect to the fusion time.

You instantly go into what can cause some little rupture or something else but it will quickly go back to the gravity force.

I don't understand the second model. We have no excess pressures. We have nothing to indicate that we have a strong coupling between stress.

DR. KING: I believe I may be in deep water so I might have to appeal to some experts in the audience.

DR. DOMENICO: We're not caught between two boundaries.

DR. KING: The excess can come from; one, hydrothermal. The other one, the excess can be created by the seismicity itself, and, the third one could be lateral flow from an area of higher ground.

DR. DOMENICO: We call that a topographical system.

DR. KING: So it could be some combination of all three but the middle does have the implication for the stability.

It is fair to say it's been the subject of intense scientific debate and the project is trying--

DR. CORDING: Of horizontal stress and not vertical stress, is that correct?

DR. KING: I believe so.

DR. CORDING: And not on low angel fractures or permeable zones that carry water?

DR. KING: I believe that is correct.

DR. CORDING: So the flow in a horizontal system would not be affected by that model; is that correct?

DR. KING: Yes. I think that's a fair assumption but if I'm wrong, somebody help me out. I think that makes sense to me, yes.

DR. WILLIAMS: It's very likely we're going to find faults that we haven't recognized up to this time. Are you saying that your confident that any fault that might have more the 5 cm of displacement during a future earthquake would already be recognized?

DR. KING: Any fault that has a probability of 5 cm or more displaced in any 10,000 year period would have surface geology.

Assuming the fault may be active for some time; you know it's a new fault, it's the first time it's ever moved, you clearly can't detect that the probability of that happening as a consideration.

DR. WILLIAMS: I hope your right and I like the argument. I have a feeling and I hope we're going to be surprised.

DR. KING: Everybody recognizes--and I think it's worth pointing out--faults underground will probably be avoided because they might form conduits for ground water so; yes, we expect to find any number of minor faulting fractures in the ground. It can't be avoided.

Thank you very much for your time.

DR. BLANCHARD: Jerry just came back from vacation to give this talk.

We were planning on breaking for lunch now and getting back at 1:15. What is your preference?

CHAIRMAN DEERE: I think 1:30 is more realistic.

DR. BLANCHARD: Please be back at 1:30.

(Whereupon, after a lunch break, the

presentations continued as follows.)

DR. BLANCHARD: It is 1:30. The first speaker will be Bill Wilson.

DR. WILSON: My name is Bill Wilson and I'm going to be presenting an overview this afternoon of hydrologic conditions at the Yucca Mountain site and the region around Yucca Mountain.

As with Mr. Dobson this morning, there are a number of colleagues in the audience who have dealt with very specific aspects of this program and if there are questions as such, I may direct them to the proper person. I have you can develop a dialogue.

Also tomorrow we will have some of the project people on the field trip and they can further explore details of the technical aspects of hydrology.

My talk is organized by five major topics and, as you can see, covers quite a range of subjects here.

I'll be discussing the regional hydrology; site hydrology of the saturated zone, and then focus it on site hydrology of the unsaturated zone; and then turn it to paleohydrology and paleo- and future climate as it relates to our hydrologic concerns.

These are the major components of our discussion. There are some others that we are studying and I may touch on them briefly but they won't be a major part of the discussion.

These include the surface water hydrology and some aspect of the hydrochemistry and I'll also touch on travel time.

Each of the major topics I will introduce them by a slide.

I think this particular component of hydrology of our total site characterization is important to waste isolation and at the end of the talk I will conclude with a summary of some of the major hydrologic questions that I think need to be of concern and of major interest to the program.

Then, after I'm through, Bill Dudley will come on and backtrack a little bit and discuss some aspect of the stability of the water table and various considerations going into that part of our program.

I'll start with regional hydrology. This is significant for waste isolation for a variety of reasons. We need to have some understanding of the regional system and hydrologic components of the system in order to understand the context in which Yucca Mountain occurs.

We will be doing modeling of both regional and site scales.

We need to establish boundaries that are appropriate for modeling at the site scale and our regional modeling helps us do that.

We also have heard today and yesterday about the potential of climate and tectonics. Certainly climate is a regional aspect of the system and it will effect the hydrology on a regional scale so in order to assess the impact in the vicinity of Yucca Mountain we need to have an understanding of what those would be and the same is true for tectonics.

Finally, to help us evaluate the potential effects of ground water that might be proposed or might occur, we need to understand regional context of any changes that might occur in Yucca Mountain.

All of these specific requirements do require some understanding of the regional frame work and the system.

I summarized for you here the stratigraphy units described in the literature. It shows the ages of the units, the geologic units, and the grouping of hydrogeologic units.

These units are basically two major types. These units retard the flow of ground water and generally in this region they consist of clastics deposits, shale, quartzite, and they're limestone, of course. They're highly fractured when they occur in the saturated zone.

Note the lower part shown in the darker blue and I'll show you a map in a minute of the general extent in the Yucca Mountain Region and we know it underlies part of Yucca Mountain by virtue that it penetrated that unit.

DR. LANGMUIR: Is there any information on that? Is it fresh water?

DR. WILSON: Fresh water. That's the water that discharges at Ash Meadows, for example.

This is a map that shows the distribution of these major hydrogeologic units shown here as alluvium, which is a widespread covering in the basin.

By now you can find Yucca Mountain for yourself although it is not identified here. It is right here. The volcanoes occur primarily to the north and west of Yucca Mountain.

The very dark area here are the clastic aquitards, which occurs northeast of the Yucca Mountain area.

DR. DOMENICO: Are the volcanoes continuous down to the California border or don't you know?

DR. WILSON: No, they're not, and I'll show you a cross-section.

DR. DOMENICO: Alright.

DR. WILSON: Now, the carbonate aquifer occurs to the east and northeast but they do exist in the sub-surface down toward the California line.

Now, we can superimpose the system under this spring work that I just described in the form of potentiometric. The numbers here are in hundreds of meters above sea level so it's an altitude--these have been mapped or were defined by scattered holes that are toward a variety of units so they do not necessarily represent a single unit but they're kind of lumped.

They were used in modeling for this project but they do indicate some very definite characteristics.

You can see in the area northeast of Yucca Mountain there's a very large hydrologic system that responds to the clastic aquitard in that area.

You can see at Yucca Mountain there is also a fairly large grading and we'll discuss that later.

In contrast, the area that is underline by the carbonate aquifer reflecting the high--

Well, also shown here are some dashed white lines that reflect boundaries of subbasin that have been identified and were used in some of the early modeling.

Yucca Mountain lies in what has been called the alkali Flat Furnance Creek Range Subbasin. Quite a mouth full. In fact, we're trying to simplify that.

This is one of the many sub-basins that have been identified Death Valley Ground Basin, which is the discharge area for the surrounding region.

Now, I want to comment again that this is a simplified version. It really represents a concept that says the flow system is a single flow system in a third dimension as we'll see in a minute.

It really is a lot more complex than that. We're looking at probably more than one flow system in our future modeling efforts.

I'd like to focus you a minute on the Alkali Flat Furnace Creek, the one in which Yucca Mountain occurs. Traditionally it's been believed that the primary area of recharging is to the north by Mesa nd beyond that where the altitudes are higher, 5,000 to 7,000 feet in altitude, where Yucca Mountain is 4900 feet along the crest.

Precipitation in this northern area may be probably more than double that of Yucca Mountain and similar to what's shown here in a rather dark slide, juniper is the type of tree that is found where in Yucca Mountain it is not the case by any means.

Major recharge may also occur and probably has occurred in the past through the large wash--that's normally a dry wash--a 40 mile wash shown here in a view looking south. This is the wash we're talking about. Yucca Mountain is off the picture to the right. We will cross this wash as we take our field trip tomorrow.

In this wash the trench is several hundred meters wide and 25 meters deep.

Now, in addition, still talking about the recharge, some area recharge to the saturated zone probably occurs a minor amount of infiltration in smaller washes and in outcrop areas beyond Yucca Mountain itself.

Now, tomorrow we'll be discussing in detail, in more detail, some of our infiltration studies at Yucca Mountain, which are intended to assess the distribution of that infiltration at Yucca Mountain and topographic and geographic controls of that distribution--and as a teaser ahead of time, I will say it is interesting to know that in the preliminary findings to locate infiltration beneath the small washes at Yucca Mountain, it has not been located.

Well, the other end of the flow system is the discharge. Discharge from the Furnace Creek occurs where the water table is shallow at a place called Franklin Lake. Alkali Flat, which is part of the name of the subbasin and that flat area is shown here in the white deposits where transpiration has been estimated at more than 35,000 cubic meters per day.

Estimate that at about 5% of the total discharge from this subbasin occurs in this general area.

The next slide, which is located in the playa, the Franklin Lake Playa. As the name applies, the initial definition of the subbasin included discharge at Furnace Creek Ranch, a spring discharge. This is in Death Valley. It is labeled as FCR. At about 35% of the total discharge occurs at that site. About 19,000 per day.

However, on the basis of the data that has been obtained an alternative for this system that suggests that this discharge in Death Valley, Furnace Creek Ranch, is from a deep confine and not the volcanic system which is the flow system in which Yucca Mountain occurs.

Some clarification of these boundaries is important from the standpoint of it does effect the amount of flux that may be occurring in the saturated zone beneath the site and so this diagram does reflect that most recent suggestion for a re-definition of the subbasin.

Note also that it only occurs on the south part--that we're most concerned with--since it's the downgrading of the flow system.

Now, these values that I referred to that were obtained from commercially drilled wells in which we had access, and they indicated that beneath the Green Water Range in the very southwest range, the head is about 800 meters, 700 meters above sea level where, in the Amargosa Desert, further to the north it is 600 meters above sea level.

The next graph is a conceptual. We haven't got to the real thing yet because we don't have a lot of information, as you already gathered, but this is an east-west section and it's intended to illustrate several concepts of flow.

It does indicate to the probable folding and thrusting that occurred in the Medazoic time of the rocks. It indicates, as you can see in the key, these are undifferentiated alluvium sediments of tertiary. These are paleozoic.

What we're trying to indicate here is that there is the potential for new flow of ground water moving through the carbonate aquifer and discharging at Furnace Creek Ranch Spring. These springs are the well known springs at Ash Meadows where considerable amount of discharging occurred from the Ash Meadows carbonate aquifer.

Here you see a representation of north-south flow occurring from Yucca Mountain down toward the Alkali Flat.

DR. DOMENICO: Does any of the carbonate aquifer water escape?

DR. WILSON: We don't reflect that as probably.

DR. DOMENICO: Up--

DR. WILSON: And out.

DR. LANGMUIR: You mentioned there was a substantial change of the position of the ground water for the basin. Based on what evidence?

DR. WILSON: That was primarily information.

One way to test that would be to re-examine the water quality characterization of the spring discharge at Furnace Creek Ranch and compare it to other data.

DR. LANGMUIR: That would be very different from the carbonated and a tuff system?

DR. WILSON: Yes.

Now, this suggestion of a deeper underlying system through the carbonated aquifer system as opposed to an alluvium, and further note another cross-section later, tuffaceous flow system, indicating that it would be more realistic to model this in three dimensional and the ideas are planned.

We have done a preliminary three day model and we plan to pursue that as more information becomes available.

Let's turn to the site saturated zone hydrology focusing on Yucca Mountain.

This component of the flow system is important because it does contain the final ground water flow path from the mountain to the accessible environment; although, less reliance is placed on the saturated zone of Yucca Mountain then the unsaturated zone.

Both, in space and time, have potential, as you heard this morning and heard elsewhere, for flux, and in order to be able to access those kinds of changes that might occur for whatever reason, we need to have an understanding of hydrology in the unsaturated zone beneath the site.

This is a map of Yucca Mountain, the tuffs are shown in the dark and alluvium is in the orange. All shown are the blue contour lines which represent the configuration of the surface beneath Yucca Mountain.

I point out that the contour is variable here. There is a 10 meter--this is in meters above sea level--730, 740, but it finally changes to a 100 level interval so you can see there are quite contrasting associated with the Yucca Mountain site.

CHAIRMAN DEERE: Which of those are associated with the volcanoes and alluvium versus which ones would be controlled by--

DR. WILSON: There's only one well in the carbonated.

CHAIRMAN DEERE: Is it shown here?

DR. WILSON: The head is the tuff and I'll tell you about the tuffs in a few minutes.

CHAIRMAN DEERE: That takes me back to the diagram that you showed before with the arrows that you showed. That now becomes very important, what the head is down in that carbonated beneath that mountain. We may well be feeding that mountain.

DR. WILSON: I'll get to that in a minute.

So there are two contrasting ingredients to the north and west. If you make a straight perpendicular line to the south and east, it is almost a flat surface at 730 meters, more or less.

The white dots on here is what we used to construct this map.

On the field trip tomorrow we'll be talking about these water levels and what they mean and problems we're having with them and what we're doing about them.

DR. LANGMUIR: How much noise is this? This is a composite map, all depths and the tuff below, the saturated zone, are defined here. How much noise is there drawing the contour map?

DR. WILSON: I'm going to get to that. Ten, twenty, forty meters, but that is not included on the mapping but that same well penetrated the rocks. We used the head from that volcano.

DR. DOMENICO: Are the waters moving east?

DR. WILSON: That would be the impression that you get from the grade, from the flat part of the grade, and it's pretty questionable which direction right now.

The large grading right now is one that we want to develop an understanding of why it is there. Is it a permanent feature? Is it something that is controlled by geology or stress or what is the basis for it, and we do have several hypothesis that could be created that would retard flow. It could be a barrier created by a fault; some dike that would serve the same purpose; or it could be related to something in the stress field which effects the fracture that controls the permeability of rock units so we have a program, as you'll all learn this afternoon or discussion that is intended to test these various conceptual hypothesis.

DR. WILLIAMS: I just want to make sure, you took the head measurements as you went through the tuff?

DR. WILSON: Well, the well is closed off so it can be measured separately from the line composite.

DR. WILLIAMS: So the head you show is the head during drilling as you went down?

DR. WILSON: I don't remember whether it's the head during drilling or afterwards. I suspect it's afterwards.

DR. WILLIAMS: So your doing the paleo--

DR. WILSON: I can check on that. We can get the details of where they came from. In some wells there have been measurements in isolated intervals at various depths in the well--we'll point these out to you tomorrow.

Well, I think it is one of these two. Four are being monitored with depth and the head in the deepest of those four is 54 meters higher than the head in the shallowest of those four and all of these are in the tuff.

There are two intervals that are being monitored. The deeper one is 22 meters than the shallower one; and, while P-1, which is the one that penetrates the carbonate, and the paleozoic is 19 inches higher in the tuffs so in all cases where we have multiple measurements with depths; the depths indicating the potential for upward flow, upper from the paleozoic, upper from the tuffs.

There was a general question this morning about response of water levels to various processes. We do have data from our observation network at Yucca Mountain that there are short nuclear wakes that do occur induced by various anomalies, parametric changes, and seismic waves which may be caused by underground nuclear explosions or earthquakes.

This slide shows the water level that responds to seismic wakes 70 kilometers away and the detonation time is indicated by the vertical line zero on the graph and you can see that the water level fluctuated in an oscillatory matter for some 90 seconds or so after the detonation.

The scale on the left is in millivolts. The frequency is plus or minus a half a centimeter. We're not talking about a big movement, a very small amplitude fluctuation.

Now, these kinds of responses have been experienced in other wells, not all wells, and what we intend to do is we can use this kind of response and magnitude and the tops of the patterns develop to make storage characterizations of the rock unit and it's response to changes.

The next slide is a view of of Devil's Hole, which is a cavity in the limestone along the fault line down in the Ash Meadow's area. This is not Yucca Mountain. This is way south and you can see the water surface, there's some divers in there.

We have a recorder to monitor for the fluctuation of the water table and although this is not at Yucca Mountain, I show it here because the analyses of water fluctuation at Devil Hole in response to seismicity and the role of faults and flow channels and flow channels in response to strain.

The next slide shows Devil's Hole. We have at the top earth time to fluctuations and response. The middle there is a water level near Devil's Hole and the bottom graph is the water level at Devil's Hole itself.

These were taken last June and there's been concern about the amount of filtration of the water hole fluctuations to get out the noise from other parametric changes and what's left are the cycles per day.

Now, the fluctuation at Devil's Hole is on a fault. It suggests that this water level is a sensitive indicator of strain changes.

Actually the total record of Devil's Hole, there have been placed, to interrupt to reflect worldwide global events so what we hope to do with this kind of record is to contact the compressibility, storage property of the fault and transfer some of this understanding and maybe be able to do some similar kind of analysis in the faults at Yucca Mountain.

Now, to Yucca Mountain for a minute. This is a geological section at the site of three wells known as the C wells. Two of them are shown here. One of them is incorrect. It should be C #1 and C #2.

These are well sites east of the repository block area where we have billed them as a trio.

What we're trying to do with this is obtain detailed information about the fracture and faults at this site.

How to relate the fracture properties to the hydrologic properties and then through transfer tests, our intent, if we are able to extend this information in other bore holes at the site, and we're learning more about this particular three hole site, the C site, at our field trip tomorrow.

DR. CARTER: What's the distance?

DR. WILSON: A couple meters. I can't remember exactly but he'll have a sketch for you tomorrow and we'll check that.

The next view graph, please. I'd like to return to this map to show location of the north-south hydrogeologic section, which is a section that shows a concept of how the saturated zone system flows beneath Yucca Mountain, if it is into the other regional picture.

Again, remember this is highly conceptualized. We don't know these faults. We're showing the stuff in brown. Some tertiary. These are paleozoic rocks of Franklin Lake Playa.

Paleozoic rocks are being thrusted and the flow pattern, as we visualize it, is lateral into the alluvium perhaps into these paleozoic rocks and on the south we're quite sure the water at Franklin Lake Playa is in transpiration.

We have a flow in carbonated rocks perhaps localized in to major blocks separated by units as a result of the thrusting and an occasion of perhaps an upward head just from our sparse data.

Also show here is a detachment fault which has been postulated as a nature of the fault that was encountered in P 1 when this carbonated rocks were drilled into.

DR. DOMENICO: Based on that, do you agree the the most probable path of escape is through the saturated zones in Calico Hill, through Calico Hills into the alluvium?

DR. WILSON: Correct.

DR. DOMENICO: And maybe through that mountain, that is clearly what your potential is, that is clearly the most probable escape, through the saturated zones?

DR. WILSON: That's right.

DR. DOMENICO: Has that been included in your travel time?

DR. WILSON: The travel time calculations for the saturated zones of ours, they're only for Yucca Mountain to 5 kilometers out. That's the boundary of the calculations.

DR. DOMENICO: Why is there so much concern about the carbonated system with the possible exception that you might get a leak from alluvium but then again--

DR. WILSON: We don't have a lot of data. We don't know if it's prevalent or if there is any place if it's not.

DR. DOMENICO: Thank you.

DR. WILSON: The other concern is related to what you heard this morning, it's potential to deep seeded ground water moving upward into the system and what controls are on that and how often that might occur but from a strict hydrogeologic perspective, this is what we visualize now and the only role that the carbonated would be is to provide leakage into the system, which would need to be accounted for.

DR. DOMENICO: You have no idea on the distance from the south end of the design to the contact of the rock and alluvium?

DR. WILSON: I think there is a fairly good definition of surface geological mapping.

DR. DOMENICO: What kind? I see no scale.

DR. WILSON: That's right. That's purposeful.

DR. DOMENICO: What are we talking about?

DR. WILLIAMS: From the site to about the location of Highway 5.

DR. DOMENICO: How far is that?

DR. WILSON: That's approximately 7, 8 kilometers. It's beyond this point.

DR. DOMENICO: That would be equivalent to Calico Hills?

DR. WILSON: Whether it's Calico Hills or--

DR. DOMENICO: Any exploration program designed for that, to determine what is going on in the hole?

DR. WILSON: Yes, of course. We have additional plans and you'll hear more about those and the mapping but as far as deep holes, we don't have any specific ones designed to go deep into the paleozoic rocks, and, although we have provisions and site characterizations to reconsider that if--we're doing analyses in the regional flow system and that is demonstrated. If we need it, then we'll incorporate it.

Moving up into the section now to the site unsaturated zone hydrology. I think, by the way, the significance is apparent. This is where the repository, of course, would be located.

The unsaturated zone is being counted on or is expected to be the principle natural barrier but it's also possible that the unsaturated zone may contain pathways for gaseous transport and possible escape to the atmosphere with the assessable environment, which would be the atmosphere.

This slide is a view of Yucca Mountain itself looking to the southeast. In fact, what we're looking at is the upper boundary of the unsaturated zone. The crest is about 4,950 feet altitude. We'll be visiting right along that crest site tomorrow.

Well, I'm not sure what port hole that is. It's immaterial. The scene does emphasize the sparsely vegetated area of Yucca Mountain, the arid conditions that exist at the site.

The ridges in the background, as you move back to the east, are repeated fault blocks. To the joining basin is about 300 to 400 meters.

The slopes in the foreground show the tuff layers you've been hearing about. This is the nonwelded unit and below that is the Topopah Spring, which is at the southern part of the Yucca Mountain area.

This is a cross-section that was taken and somewhat simplified and it provides us with the basis for the unsaturated zone at Yucca Mountain and it shows the layered units, the boundaries for the unsaturated zone or the land surface at the top and water table at the bottom and to the east, an increase of the fault structures are shown there.

The thickness of the unsaturated zone in this particular section ranges from about 500 to 575 meters, very thick in the unsaturated zone section.

The approximate position of the repository, of a design repository, is shown in red. This is not a scale. It's simply indicated to indicate potential location within the unit.

There is only one major fault, based on the mapping, that's been done.

Now, the units shown here in orange and green are the generalized hydrogeologic units and are trying to identify the appropriate units to use from a hydrogeologic standpoint, and, basically they're based on the amount of welding.

These have specific and contrasting hydrologic properties due to the differences in major welded units. The ones in orange have a fracture of ten or is up to forty fractures per cubic meter. They have a low saturated matrix activity that can be expressed as 1 millimeter per year. They have a low of 10 to 15 percent in the saturation.

In contrast, the nonwelded units have no fracture density, 1 to 3 per cubic meter, and these units have a saturation, as you saw yesterday in some of the diagrams, up to as high as 90 percent.

The Calico Hills unit has been further subdivided and these have contrasting results.

What I would like to do is superimpose the hydrologics in a conceptual way to this framework that we just described.

This diagram shows various alternatives, flow patterns, that might occur, as indicated by the various arrows on the diagram.

We can start with precipitation at Yucca Mountain. Precipitation has been estimated at 150 millimeters per year. Perhaps a little higher at this end of the mountain.

As is typical of an arid region, all of these return to the atmosphere; however, some of it does become run-off and there are some types of precipitation.

In small amounts it becomes net infiltration and they escape the discharge back to the atmosphere and they move downward through the unsaturated zone eventually charging the saturated zone at the water table.

There are a variety of estimates of how much this net infiltration is at Yucca Mountain and Range from the western, half a millimeter to four and a half and perhaps I'm not sure--the average of the unsaturated zone probably is very minimal resulting from redistribution of the water flux percolating in the sub-surface.

Let's look at these possible flow paths as it goes down through the sub-surface.

Usually the unit that it infiltrates into is going to be alluvium or Tiva Canyon, perhaps with a very thick amount of soil.

It's possible under intense rain fall conditions to occur that water may infiltrate into the Tiva Canyon downward toward the first nonwelded unit, which is known as the Paintbrush nonwelded unit.

Now, with a nonwelded unit there is a potential for lateral flow to occur along the surface of this nonwelded unit and within it as well. That's a structurally favorable location, where water may develop probably temporary.

This, in turn, may lead to increased flow and flux down the fault such as the Paintbrush or other faults further to the east--Ghost Dance, not Paintbrush Fault, and somehow does percolate into the top.

This is the Topopah Spring welded unit, and the repository horizon, if it's constructed, would be built within that unit.

DR. WILLIAMS: Can I ask you a question? The water that percolates, does it go to the saturated or unsaturated or both? Particularly is the testing program designed for one or the other?

DR. WILSON: Are you referring to this?

DR. WILLIAMS: No.

DR. WILSON: Within the fault itself?

DR. WILLIAMS: Are you testing the unsaturated flow or saturated flow?

DR. WILSON: The Ghost Dance Fault will be penetrated from the exploratory shaft so we'll be drilling through this fault zone and conducting tests, hydrologic tests, sampling whatever you can find so we will have a chance to observe it.

We also have more holes to be drilled on either side of the fault but those are primarily to be looked at for water and lateral flow.

I'm trying to think if there is any other tests designed--

DR. WILLIAMS: What about the radium tests--

DR. WILSON: They won't penetrate the Ghost Dance Fault. They may penetrate other faults but the Ghost Dance Fault won't be penetrated. It's to far away.

DR. WILLIAMS: So it's going to be the penetration from the drill as far as movement is concerned, just that one shot?

DR. WILSON: That's my recollection.

Now, in the Topopah Spring in the main part of the unfaulted block, most of the flow is probably vertical. By the time it reaches the Topopah welded unit--probably short term flux waste that is reflected at the near surface, as a result of pulse infiltration probably the short term flux is out there and there is a fair percolation rate.

Again recall, this is a conceptual model, that these kind of concepts are intended to be tested in our testing program.

We have made some estimate of the flux within the Topopah Spring welded unit based on moisture curves and I'll be discussing that in a minute about the 65 percent saturation. The flux would be less than .05 millimeter a year.

DR. DOMENICO: Matrix flow?

DR. WILSON: Yes.

DR. DOMENICO: I heard Marty yesterday. I heard Marty is for the block of the unsaturated zone yesterday.

DR. WILSON: In many ways it's similar. It's just interpretation. One of the elements of his model, that infiltration is at the surface and we have a detailed program to assess that.

We feel that the potential for redistribution of the flux is within the sub-surface. Such that a flux within the Topopah Spring unit is much less then let's say down faults or some other points of the system so that you have a variable flux in the sub-surface but in the fractured welded unit, it is probably much less than average so this would result in a lower flux, a smaller flux, within the Topopah Spring.

What I'd like to do now is to talk a little about fracture against matrix flow, because this is an issue.

We recognize and feel quite in agreement with almost everyone that we need to develop an understanding that could lead to fractured flow and evaluate whether it's occurring now and under what conditions and what distributions.

Before I leave this diagram, though, I would like to point out there is one other set of arrows that I haven't talked about. These are these arrows that wiggle which represent the potential for water vapor flow and we'll return to that later.

First, fractured flow I'd like to discuss and start--let me start by saying that one thought on this is that a vertical conduit with smooth walls and open, perhaps interconnected with water or air moving in and out of them freely. Maybe somehow the matrix blocks between them or suspended so you have these channels that go right on down to the system.

I think another, and perhaps a more realistic way of looking at these fractures that was advocated 5 or 6 years ago and is being evaluated by the survey and others, is to view the fractures as very irregular, having very irregular walls, many contacts in them, a variety of aperture sizes even within one fracture, where rings of water are around the contact points of these fractures, that, as the flux increases or the saturation increases, the size of these rings of water may grow and flow along the fractured wall and absorb into the matrix.

Now, one of the ways to express the relationship between saturation and flux is through moisture character curves. One for fractures, this curve here, and the other solid line for the matrix and a dash line for a combined system and what this shows, as you increase liquid saturation in this direction of the permeability, the matrix or fracture also tends to increase.

The composite curve represents a way of perceiving what happens when you have a fractured rock mass at low saturations, the flow is predominately in the matrix.

At some point when the saturation increases, you reach a critical point where the two curves cross and the flow is predominately in the fractures.

This type of concept assumes there is some moisture in the fractures itself. The fractures themselves and the permeability is increasing in the fractures and the matrix and saturation increases.

Now, what we need to do, and we have started doing this, is to define moisture character curves for a particular rock type, the rock units that we observed at Yucca Mountain, and we need to determine the saturation content.

I remember in the unsaturated zone if the flow is vertical and then the permeability or flux are equivalent, then these curves are going to be shaped differently. This critical point is going to occur in different places on the curves for the different kinds of units.

It appears, for example, that even with the large saturations that occur on the unwelded units, the matrix flow still prevails.

DR. DOMENICO: Are you sure you can determine matrix? I know you can do it for the matrix but everything you have said is based on whether the fracture continues to maintain some suction.

Can you actually determine matrix from fractures?

DR. WILSON: The plan is to do laboratory work on fractures from the exploratory shaft program and to test the fracture flow properties of characterizations and the varying degrees of saturation and try to relate these to the fracture properties themselves, these fracture characteristics, if you will, and use that as a means of going into a larger scale.

We have plans to take numerous samples that will contain single fractures and test them and use a larger scale and larger blocks to try to assess the likelihood or the conditions.

DR. DOMENICO: Have you extracted any water?

DR. WILSON: Yes, we have. We have extracted water from nonwelded units primarily by squeezing techniques; and, by the way, that data is published in a report.

DR. DOMENICO: Young water?

DR. WILSON: No age on the water, just chemical analysis, but, of course, that is part of our plan, to try and develop techniques so we can have sufficient water--

DR. LANGMUIR: You have ages on the carbon dioxide with that water?

DR. WILSON: That's correct. Those are published also but I don't remember the ages.

DR. LANGMUIR: I recall several thousand years.

DR. WILSON: The next diagram--I think this shows up better in your booklet than it does on the view graph. I originally had a colored slide of this but it has been misplaced.

This is another way of representing a concept of how flow occurs in a fractured median. Here the white color represents water in the powers of a matrix with the lightly shaded pattern representing air contained within the matrix.

In this case you have flow cross fractures where the fractures are in content but air flow is what occurs along the fractures, the longitudinal flow, and as long as you would increase the flux to the point where you would displace the area and get downward or longitudinal flow along the fracture plane.

Now, the circumstances of air and vapor has been observed and monitored at two wells on the crest of Yucca Mountain and we'll be standing next to those wells tomorrow.

There are probably two driving forces that lead to this circumstance. One is a topographic effect where, in the winter time, you get cold dry air along the face of the mountain side. This air moves in, it's heated, picks up moisture and then rises up. This has been observed in 6 X, which, by the way, is basically closed off in this nonwelded unit and is only open to the Tiva Canyon at the top of Yucca Mountain.

The barometric effects is the other type of driving force here.

This is an operation where, as it increases of barometric pressure, air moves down and into the rock unit and it decreases the pressure and the reverse occurs, you get isolation and this is the principle event that occurs in 6.

DR. DOMENICO: Has Ed Weeks worked out there?

DR. WILSON: Ed Weeks is making this test. He's doing the work here and I'll tell you what he's finding out.

Usually 6 X is the most interesting because it is in fact showing discharge of air and moisture from the mountain.

We have monitored the flow and moisture in and out of this bore hole for more than a year, maybe two years or so, and what's being observed, that for 6 months of the year it's a discharging bore hole, discharging air out of the hole. For 3 months it is recharging and the remaining 3 months it's osculating back and forth. It can't make up it's mind which way to go.

It moves 3 meters per second and calculations were made of the moist air that was discharged out of the bore hole and calculations were made that it was 1,000,000 cubic meters per year.

You can estimate the moisture content, estimate how much moisture, and then the net discharge and it comes out to 240 gallons per day.

CHAIRMAN DEERE: Bill, you may recall when this was presented 3 or 4 months ago, I think we had a similar experience.

DR. WILSON: Correct.

CHAIRMAN DEERE: But looking at this particular cross-section, the similarity between this case here and the other one that you have observed in Peru is very striking; that is, there is a welded tuff into which the air was blowing in and out. It outcropped fairly near where it was intersected by the well and there was a bedded tuff on top of the welded tuff so you had to have something to keep the air from equalizing rather easily with the atmosphere above.

DR. WILSON: Right.

CHAIRMAN DEERE: And that's your bedded tuff and yet you have access fairly near into the outcrop at the site and that's exactly the same situation we observed.

DR. WILSON: There is no bedded tuff above the Tiva Canyon and it's the Tiva Canyon where it is occurring.

There must be something at the very land surface that would serve as a capping unit and prevent that natural escape.

CHAIRMAN DEERE: Your not getting into the deeper holes?

DR. WILSON: It's possibly the barometric fluctuations. We don't see the same kind of topographic effect that we saw in the shallow--

DR. CANTLON: Are there caliche levels in the soil?

DR. WILSON: Yes, but there aren't many levels of soil. This is closed off.

DR. DOMENICO: Is the well open?

DR. WILSON: Only to the welded unit.

CHAIRMAN DEERE: There has to be a confinement or caliche or perhaps--

DR. WILSON: The other interesting thing, and this is all still preliminary, but contained with the discharging is a very high amount of carbon dioxide and Ed speculated the only likely course is this sparsely flat ground on the down dip side of the ridge--he speculated that there is some access of air that's carried in somehow. I really don't know what the mechanisms would be to provide that carbon dioxide.

DR. DOMENICO: The Schelor Well is penetrating but it does not--

DR. WILSON: It's collapsed.

DR. DOMENICO: How about the bottom, is the bottom sealed off or is it opened?

DR. WILSON: It's collapsed.

DR. DOMENICO: How do you know?

DR. WILSON: It's the Tiva Canyon.

DR. DOMENICO: How do we know?

DR. WILSON: I don't know. It could be. It's hypothesize is that it's from Tiva Canyon.

DR. LANGMUIR: Has anybody looked at the carbon ratio in the Co2 because that's a clue.

DR. WILSON: He may well have. I don't know the result of that.

In any event, regardless of the specific mechanisms, I'd like to comment on the significance of this because, first of all, it suggests that the bore holes themselves have greatly enhanced what may be a natural process occurring within the system but obviously bore holes have changed it significantly.

This in turn might make monitoring a basin in Tiva Canyon difficult to do if we altered the natural conditions there.

On the other hand, we are in the process of using this phenomenon and monitoring it and testing it to develop models that can be calibrated.

Hopefully, we will be able to model these units. Of course, the other significance is that if this process is also occurring in the Topopah Spring and there is a natural outcrop in the Solitario Canyon area, then this could be enhanced by the presence of the repository and the heat that would be generated from that repository so this is rather preliminary but I presented it because it offers another way of looking at the vapor flow that may occur in the unsaturated zone.

DR. CANTLON: Is it possible that the two values that you're looking at are really a reflection of a loss of oxygen of normal air from respiration and the soil?

DR. WILSON: Possibly.

DR. CANTLON: Your looking at a changed balance of gas. You may be looking at an extraction of air and bacteria.

DR. WILLIAMS: Can you reiterate what the deep well is doing? I think I know what you said. It might be the most important one really.

DR. WILSON: The deep well which penetrates down into the nonwelded Calico Hills is breath related to barometric pressures.

As barometric increases, the air moves down and into the rock because there's a more rapid path than trying to work it's way down through the rock and surrounding the bore hole.

As the barometric decreases, the reverse occurs and the air discharges.

CHAIRMAN DEERE: And it goes through the welded Tiva Canyon?

DR. WILSON: Yes.

CHAIRMAN DEERE: So this definitely is from the welded Topopah Springs?

DR. WILSON: Well, it, in effect, is generated by the fact that you penetrated into this fractured welded unit and it is permeable to air flow and so, as flux, this air flow occurs within the welded unit.

CHAIRMAN DEERE: This is contrary to what you gave a minute ago. Were we speaking of 6 X?

DR. WILSON: The barometric flux occurs here, both occur here, but the predominant effect is the topographic effect of having heavier cooler air outside moving in and up the bore hole. It's a seasonal thing. It's more a seasonal thing than barometric.

DR. CORDING: Have you been able to get a look at the volume in U6? Is that going to be able to give you some clues as to the relative air permeability of the two zones, the lower, and as compared to the Tiva Canyon?

DR. WILSON: It doesn't appear to be any net discharge from U6. It's just a breathing in and out type of thing.

DR. CORDING: In terms of total volume, it can go in and out of there?

DR. WILSON: Probably there's an analysis that can be made.

I'd like to change topics now so we can move along and discuss briefly travel time calculations that were made as part of the assessment that was made several years ago.

As you are probably aware, there is a performance which relates travel time along the fastest path from the disturbed zone to the successful environment. It shall be at least 1,000 years. In addition, there's a favorable condition that says it's favorable if that ground water succeeds 1,000 years.

As part of our environment analysis, travel time was calculated, based on the available data at that time using a probability method for distribution, and this map shows the product, which is the contour map of the ground water travel times from the disturbed zone defined for this area as 50 meters beyond to the water table.

We're only talking about unsaturated zones and the range is from 20,000 or less than 20,000 to 70,000 and so increasing years, that is, increasing toward the southwest, reflect the general increase in thickness of the unsaturated zone in that direction.

The next graph shows another way of expressing that. The area of Yucca Mountain, for purposes of this calculation, was 960 columns into ten foot thick elements and this is calculated by the columns and you can see that most of them fell within the 30,000 to 40,000 range.

Now, many assumptions and many details of the statistical analysis that went into that went into this characterization and these are all explained in the 1986 paper, the same year as the report, and so I'll refer you to those, if you have questions of the assumptions and details of these calculations.

Turning now to paleohydrology and paleoclimate. Why is this significant for waste isolation?

Well, for one thing, it refers to the projection of quaternary processes. A favorable condition in that document states that the nature of the processes in the quaternary, when projected, would favor waste isolation, so that is a favorable condition.

There is also a potential adverse condition that says if there is a potential for conditions, it would effect migration and one of the major driving forces of such change could be the climate.

Climate could effect hydrology in a variety of ways. It could change the flux to the unsaturated zones. It could change the position of the water table, the level of the unsaturated zones, and increase run-off at the land surface.

We'll start with some of the older features. There are various lines that suggest that the water levels have fluctuated during the past few million years and at times they were higher than modern day water level.

This graph suggests that there were past conduits for ground level discharge. The tops of these veins are about 100 meters higher than the modern tops. These veins have been 900,000 years and greater.

They also believe the position of these deposits is due primarily to the up-lift of terrain rather than actual water table lowering since then but they also postulate that there has been a long time lowering of the water level due to the studies of the surrounding mountains.

The seas have risen during the last 3,000,000 years. This resulting in a general overall increase in humidity.

Of course, superimposed on this long-term trend or cycles, water table levels have declined none associated with the paleo period.

The next slide shows a sample. This is a sample taken from Devil Hole. You saw the hole of Devil's Hole and the water level at Devil's Hole. This was the rock wall. This is in a room called Brown's Room that has been accessed by the divers, which has a water level and air above it. This is taken from about 20 feet above the water level in Brown's Room and here you see a series of pictures reflecting various periods of deposition.

These samples suggest that the water level at some time in Brown's Room was at least 20 feet higher than present day.

There have been oxygen profiles made of these samples, these and those that are also found below the water level, which indicate cycles of light and heavy ground water in terms of oxygen.

The veins have been dated but we're getting completion results that don't agree with the other dates that have been made but, in any event, it does suggest that the water level was higher. One date is 30,000 years before present. Although there is some question about the validity of that date.

There are other materials in the region that could potentially be used to evaluate former water positions and I will--in the interest of time and the interest of Bill Dudley who is going to discuss water table rises shortly, I will cut this part of the discussion short.

Another approach to hydrology is to look at the deposits that occur in Trench 14. These are calcite silicone deposits that are exposed in the faults near the surface, as you have seen earlier today, and yesterday.

The current project is that these result primarily from shallow pathogenic processes and they're alternative hypothesis you've heard and you'll visit the site. We'll visit tomorrow and we'll get into a more detailed discussion of these deposits.

Turning now to paleoclimate. This is a major driving force on hydrology. The distribution of precipitation and temperature and evaporation effect it right off and we know that climatic fluctuations did occur and are likely to occur in the future.

The next slide lists the sources of paleoclimatic data. It lists certain advantages and disadvantages and our plan is to utilize a whole variety of approaches and to develop a consistent climatic history.

I provide you now with a summary slide listing a variety of estimates that have been made on these types of data and these are published values, much literature, and it shows some values for precipitation and temperature during late Wisconsin Time, 25,000 to 10,000 B.P.

The slide shows that temperatures were cooler and precipitation mean annual has been X times twice and as much as five times and the result is five times very very little is still very little.

At Yucca Mountain the estimate is probably 2 to 2 1/2 times the precipitation.

Of course, the key is to predict future climate and to make these estimates.

We're taking two approaches. One of them is simply to use the amplitudes and frequencies of the past climates and project them in the future. Now, this does not take into effect such modern day problems as the Green House Effect or other changes, man made changes.

A second approach is to use physically based numerical models to estimate a range of future climatic variations.

These will use a variety of methods to simulate conditions that are different from today so in summary, then I would like to conclude with a list of some of the major hydrologic questions that I think the program is addressing and that we feel are important.

The stability of potentiometric surface. Certainly climate must be evaluated because of their possible impact on isolation and Bill Dudley will discuss these in greater detail.

The flux and flow paths in the unsaturated zone are important. Is the question of the flux rate the potential of the lateral flow faults? The redistribution, does that occur and how significant is it? It may result in a small flux and a larger flux.

There is the potential for radioactive cases from the waste package and circulation of the atmosphere and this requires that we understand the air circulation mechanisms under both natural and repository conditions.

We talked about fractured flow in unsaturated conditions so we need to know--and this does control travel time and then impacts of the future climate and tectonics on hydrology--we need to know the frequencies and the durations to assess the impact on isolation.

Thank you. I'll entertain questions now.

DR. LANGMUIR: Earlier you showed a graph of travel times from the disturbed zones to the water table.

With an average flux assumed of .5 milligrams a year, what if we introduce to the model the data pertaining to the annual precipitation, which is five times the modern precipitation rate, what does that do to your travel times?

DR. WILSON: As I recall, there was an analysis at 1 millimeter per year and it did reduce them but still well above 10,000 years, as I recall.

I don't know that an analysis has been done in a much higher flux rate. At this point it would likely increase the fracture and shorten it substantially.

DR. WILLIAMS: I think it's important to realize that he is assuming your former vertical flow, right?

DR. WILSON: No. Uniform flux.

DR. WILLIAMS: Flux, I mean.

DR. WILSON: But the variables involve hydrologic activity and the effect of velocity of the matrix and these values were selected by random for each of these units and if the flux set the value of saturated hydrologic activity, the fracture flow assumed was used in the action.

If it was less than 5 percent of the saturated, the matrix flow was--

DR. WILLIAMS: It's one dimensional, vertical?

DR. WILSON: That's correct. It did not take into effect lateral flow or redistribution. Of course, our plan is to revise it.

CHAIRMAN DEERE: Bill, on your list of the major hydrologic questions, you haven't listed the model--

DR. WILSON: The conceptual model is being questioned, yet, when I see my permeable, the limestones, the idea that it may have sufficient surface to allow the water to enter or to drain it away and it seems to me this a contradiction for the model, which could make quite a difference.

What happened in the change of climate? Is it going to change the water levels within the limestone units, it certainly should, but testing a model is basically inappropriate but I agree, it's an aspect of substance.

CHAIRMAN DEERE: We might need a couple of wells.

DR. WILSON: We might need a couple of wells.

DR. WILLIAMS: I want to ask you one more question about P-1 or would you rather I did that with some other assistance?

DR. WILSON: How about we talk about that tomorrow on the field trip?

DR. WILLIAMS: I think that might be better.

DR. WILSON: Especially since I ran over.

(Whereupon, after a short recess the Board reconvened.)

DR. DUDLEY: I am Bill Dudley, I'd like to express my appreciation for those who called for a break.

My topic is preliminary observations on water table stability and this will be a review of things you heard several times during the past day and three-quarters.

I would like to end with some speculations on the information that we presently have, what it may mean.

First of all, water table stability can be defined either rise or fall.

At the present time we do not have any reason to believe it would be consequence associated with a decline of a water table so I'll talk about water table rise.

The potential consequences of water table rise are shorten unsaturated zone flow paths, submerged repository, and local discharge to the surface.

The possible causes of water table rise, as we've identified and talked about earlier in this session, is climate change and tectonic events such as disruption of permeable pathways by fault displacement, fault connection to areas of higher potentials, epierogenic subsidence, and stress sensitive transmissivity and storage.

In addition, igneous activity has been mentioned as a possible cause of change in the water table.

It would appear that the tectonic event, igneous activity, hydrothermal activity would be relatively local where those dealing with the change of climate would be widespread.

There has been an attempt to find good evidence. The most promising, yet frustrating is working in geochemistry.

Alteration of volcanic glass preservation. We can look at preservation of glass fars. It would appear at Los Alamos that there is a good promise that the preservation of glass jars may give us some indication of past tense of the water table.

There is some indication glass jars are advantageous to the present water table so until geochemists have time to really look at such possible things, it might be that we must consider this as ambiguous evidence.

There is no apparent post-miocene hydrothermal alteration.

We have looked at uranium mobilization, and dated it as well, and have concluded in the last 400,000 years the mobilization of uranium in the unsaturated zone that we know today.

There is, however, no unequivocal evidence. The search goes on.

In terms of tectonics, it has been a geomorphic of the upper Amargosa-Fortymile by Mr. Huber. It has been geomorphic stable for the past years. This is a conflict somewhat in the vicinity of Death Valley but not in this area.

The fault movement that has been taking place--there has been a discussion of fault movement--however, this is rather minor relative to the major fault topography of the late Miocene period.

Another possible hydrothermal discharge within the general vicinity of Yucca Mountain. In fact, north of the northern edge of the Amargosa Desert, no preservation has been found so far.

It would suggest large discharges at the surface due to hydrothermal action.

It appears that the calcite-silica veins that have been looked at so far were precipitated at relatively low temperatures, and, according to many analyses, considerably less than 20 degrees.

The calcite veins will be a very active discussion at Trench 14.

Now, the present water table configuration--let's put up the map instead.

I think we have the word-view graph there and can follow along.

We have put this together from a map of approximately the same area that occurred in 1984 and combined this with the map of the Yucca Mountain site itself. Several were published by Robinson in 1984.

The principle features of this map, of course, is the large grading from the north--which Wilson also pointed out the relatively high level table beneath--it really turns out that in this general area we're really talking about a surface regional.

Over in the western two-thirds of the map the water table is very very close. Oasis Valley is the only topographic control on the position of the water table, starting from Beatty and going up to the north. Below Beatty it's the Amargosa River and in the north, the Amargosa Desert. In the southern part of the map the ingredients are extremely small.

We have a similar situation to the one that Bill described on the map earlier going at 20 meter contour intervals up to the 800 meter level and from there going up at 100 meter intervals.

DR. LANGMUIR: This is an average map?

DR. DUDLEY: South to the tuff exposure.

We don't know how far up it goes here. It is within the volcanics all through this area. This is carbonated.

The main feature that is of interest here is in the vicinity of Fortymile Wash and included within that is that part of Yucca Mountain which we're interested in.

Now, there are modeling approaches to this reported earlier by Czarnecki. Czarnecki has been discussed earlier, assumed earlier that a doubling of precipitation would result in about a 15-fold increase of regional recharge.

This is somewhat greater of the assumptions that was indicated yesterday. The results of that we can have, I think--we originally put this together Wednesday, the two maps side by side on one page.

The results show a pattern which is quite similar to that which is illustrated for the present day, with the exception being that in the vicinity of the repository, the level is about 100 meters higher.

If you can go to the second one, we can compare it. The ground flux is the vertically intergraded markings by Czarnecki and this indicates that there is actually loss of flow in the upper regions of Fortymile Wash.

Coming out going back into the ground, as Fortymile Wash passes out in alluvium and underlying tuffs, it still is similar to the present day simulation flow around a zone permeability coming in through the north part of the repository back into the western portion of the Forthmile Wash area, indicating there is a large increase of flux more than 15-fold, perhaps to 25-fold.

Now, what we have in the way of evidence of what water table may actually have done, we have some occurrences--if you put that other map that you saved--some occurrences of marsh deposit such as Marty described in his talk yesterday. Also perhaps wet meadow deposits some down south of the town of formerly Lathrop Wells, now called Amargosa Valley. About 700 meters of altitude.

Just to the southwest of Yucca Mountain and southern Crater Flat, this is not only marsh, it includes calcite as well.

We have much work to do in that area yet and just to the south of that, along highway 95, there is another exposure of the marsh deposits. They do not appear to be the same age. More than likely these down here have been dated and they are in the 2,000,000 to 3,000,000 year range.

About here in the 750,000 year range, we have nothing dateable at the present time. This appears to be as young as something on the order of 700,000 years and, at least in some of the peds, more than 1,000,000 years in age.

I think for most we can say they're very probably more than 1,000,000 years. For some, they many be somewhat less.

For that deposit in the Southern Crater Flat, we really don't know.

It is clear that for some of these, we're not talking about occurrences of probable water table outcrop or discharge to the land surface.

The fossil, some of these suggest that they're a relatively cool environment but possibly seasonal. They don't require a supply of water.

Now, if we were to consider these as dates of point--we can go to the next one now. If we consider these for the highest water table that we have any evidence for, and make a couple more assumptions--

First of all, this is the same as presently determined in the model and supported by the rather sparse data that we actually have.

This one translates into meaning we would have a similar pattern s to this higher position to the water level but it would be more elevated.

Secondly, we assume that the geomorphic stability means that the topographic, through most of this area, has been about the same through that period of time.

Now we can begin to look at now that topography might limit the rise of the water table.

Certainly the speculation and these two assumptions following the rule keep it simple, whenever possible.

If we can have the next map, we can start and look at the topographic controls.

First of all, Oasis Valley, up in the northwest part of the map again is still discharging. There can not be a significant rise in the water table there. It would be an increase in discharge instead.

As we go up away from Oasis Valley up Beatty Wash, we would find that at various altitudes up here that the water table would intersect land surface of Beatty Wash.

Czarnecki's model already predicted that it got off over here--already predicted as to this exercise--that discharge is occurring in the upper part of Fortymile Wash, as depicted in this map, that's relatively low all together and that this drainage would become--again, this was shown by Czarnecki, as arrows are going out, which is consistent with the findings on the basis of Carbon 14. This is on the order of 13,000 years.

Now, as we look at another place, the Amargosa River below Beatty Wash does not take very much of a rise, 100 meters or less, depending on where you are in order to start discharging at the surface: and, of course, we treat as control points the drainage here, which are the marsh deposits giving us discharge at about 800 meters along the northern edge of the Amargosa Desert.

In going back, I find that if we were to have this type of a rise in the water table, thinking about the various points of discharge that would occur in trying to rise, it would also intersect the surface along the access of Crater flat.

Now, we have not done very detailed testing but there has been some talk about the deposits that have been noticed. Obviously I think we have to go back and look at it in greater detail.

It does appear that the topography would limit the rise within this area, that is feasible within this area, and if this assumption of keeping the transversity would be the same as it is now and is correct following the same pattern, it would predict somewhere more than 100 meters of rise in the repository area.

This analysis does not include any of the tectonic effects, such as the change of stress, massive faults, anything of that sort. That possibly could change the situation.

If we need that 15-fold increase and flux in the system, it is quite evident that much of that is to reemerge as base flow to streams.

The Fortymile Wash embankment would still exist if the transversity would be the same as the present time. This, of course, is consistent with the Czarnecki model.

I believe that the geochemical evidence still remains on e of the most promising that we can look at it in detail not only because of the regional position of water tables within the past 3,000,000 years or so but also it gives the key to determining whether it has been more localized in water tables.

We have to first look to expect barometric increases and it appears that it is something on the order of maximum expectation.

I'll entertain any questions now.

DR. DOMENICO: If these things came back, these events, how do you view their impact? If these events came back on the site, how would you view that? Is there a problem?

DR. DUDLEY: You're talking about the localized rise?

DR. DOMENICO: One hundred meters.

DR. DUDLEY: It would still put us well under the requirements by 50 or 60 meters and 100 meters, about 100 meters on the upper end.

That would significantly shorten Calico Hills flow path and probably eliminate it on the eastern side so, I think those have indeed a possible consequence.

This would take time for this change to occur but also for the system to adjust but I think in our determination the probability that's occurring within the time frame of interest is going to be a critical aspect.

DR. DOMENICO: I don't know if this is a nuisance problem or a real problem in terms of the site, performance of the site.

DR. DUDLEY: If we would have a rise in the water table--presumably it would be similar to what we have today or even more behind, so that I expect, when you design the waste--

DR. DOMENICO: Is this Czarnecki model very sensitive to what you do within the limestone at the boundary?

DR. DUDLEY: Probably not. I don't know for sure. I don't know whether Bill Wilson can help you on that one.

DR. WILLIAMS: The 2-D model, does it only deal with the surface? It doesn't reflect two components?

DR. YOUNKER: Well, you guys have remarkable endurance.

Can I ask Dr. Deere how much information that is in your package that you wanted to cover or maybe I should just go ahead and move through it.

I will probably focus a little about the surface base characterization on the underground program so there will be a part of it that we'll skip but I thought I'd like to give credit to this plan. I'm going to give you an overview of the team work that was involved.

You heard Carl's opening remarks where he talked about all the participant's here but I want you to make sure that, by no means, were we the only participants.

I want you to understand that the staff, as well, has worked long and hard and certainly contributed, as well as the Project Office Staff, as well as some contractors that they have. It was really a huge team of people and it's a good team of people and it's good team work that we were able to pull this thing together.

Also a couple of other general comments before I roll into the presentation.

One of the things that I listened to was all of your questions.

In an attempt to approximate the kind of information we need, we're going to have to have credible regional models for the site.

Then we're going to have to go a little bit further. If you were doing an engineering job to put a facility in, one of the things you would do is look at the regional structures and then you look and go over into Death Valley and do studies and do studies in there. You have to do that and we recognize that.

On the other hand, we tried to also make sure that we have a focus on specific pieces of information like the design studies or the performance studies.

What you see--I tried to give you this overview--today is a balance between the credible overall regional type of models, we're going to have to have specific models balanced against the specific pieces of data that we're going to have to have in order to make characterizations.

That is a struggle all the way through and clearly that's why in some of our discussions today--

Alright. One last point, there is no way in an hour I can cover the whole plan since it's over 3,000 pages long.

I'm going to give you some highlights between today and tomorrow. I think we'll have enough time to give you information on some of the key areas but obviously all I can do is give you a quick glance at some of the planned activities.

The way this presentation is set up--I want to give you the direction that we went, from the standpoint of the regulatory requirement, focusing on trying to put some of the data that we have to have.

We have some organizations that deal with the regulations that we have to meet, and then we'll give you an overview of the site studies.

What's the purpose of the overall program? Clearly to obtain information to evaluate suitability of the Yucca Mountain site.

What was our overall general approach? I told you this. We reviewed and reviewed all the regulatory requirements.

You have heard a lot today about base line. Chapters 1 to 5 of your site characterization plan gives you a pretty thorough picture that we might be able to rely upon.

It also gives us a chance to set up some kind of an understanding of what kind of environment the engineers will have to interact during the period of time that they're there for us.

Take a look at what you already know. Take a look at the kind of engineering system is needed at the Yucca Mountain site.

You try to clearly focus the site program, as best you can, on the site characterizations and to get the specific site data that you need to know.

DR. COONS: You're working from a set of regulations that came on in the absence of anybody ever having built this.

Is there anything now to indicate that we might have to revisit the regulatory requirement?

DR. YOUNKER: What do I do about that question?

I think, as we're interacting with them, my guess is--and I think they would answer the question the same way--as we think about them and look at how they're going to be placed and how we'll implement them, there probably will be a need for some answers.

DR. GERTZ: They recognize that what's available needs to be changed. In addition, looking at other positions so they're recognizing things and thinking them through.

DR. YOUNKER: Just a quick review of what it is in terms of the regulatory requirements.

This is to give you a breakdown of all the records, because my presentation seems to be an awful amount of words.

We have the overall system performance for 10,000 years.

We also have our various subsystem performance requirements and what I've done is highlight the one's that we're going to emphasize today; although, I'll mention a few studies that we're getting from the environment.

We have the total system performance. We have the pre-waste emplacement ground-water travel time. We also talked about that yesterday.

We have the pre-waste emplacement. We're talking about present conditions.

You also have siting criteria, which has a series of favorable and adverse conditions that have come up in various conditions.

There's a whole list of these and these you'll get from the technical standpoint, very specific with qualitative type of judgments that we'll have to make.

I'll go very quickly. A few years ago, the DOE issued some guidelines, and that was the way to go.

It is just a translation of the regulations in the case. For example, 10CFR60, we had to convert this into a set of specifications which we call performance issues. These are just simply reflections of what the regulation requires us to do.

They're nothing more than a translation and listed them out for you and it gave us a theme for all three sites back when we were preparing the plans for the three sites.

You already heard me talk about the NRC performance confirmation for testing ground water travel times.

There are some design issues as well. That is a performance issue as well.

We also have design configuration of the underground facility because we need to have a good understanding of distribution and the rock properties.

Now, the way the SCP is set up--some of you are very familiar with this so we'll cut most of this organizational structure out of the presentation.

It is structured so Chapters 1 to 5 describe what we know about the site and break it into geology and climate.

Chapter 8, which is really the bulk of the plan of the site characterization program.

The way that Chapter 8 is set up, the issues that I just reviewed for you are laid out as a repository program, seals program, waste package program, site program, and a performance assessment program.

You get each one of the issues. It's set up "requests for site information" and the site program is a very large part of Chapter 8.

The overall approach that was used--because we formulated these issues from the regulations--was to develop a strategy and that strategy would include what kind of information you have to know in order to resolve the problem.

We used an issue resolution strategy. You get enough information having the right analyses; having the right set of kp's of information so that you can make an evaluation; a presentation where you met the requirements that that issue presents.

We're going to talk about this part very quickly so we can get-- The part that we're going to focus on is Step 6, and, conduct the investigation, which is, of course, where we hope to go very soon.

Now, Step 3, use site description and design information to determine key elements of natural and engineered barriers contributing to isolation.

Now, Step 4, define hierarchy of parameters needed to predict performance of natural and engineered barriers.

Once you have that, that's a fairly big step, getting from the first step of information that you define and you see long lists of these that are really very high level parameters.

If you will, they're not parameters that you can use measurements in most cases so when I say a hierarchy of parameters, I'm talking about taking something of value that you might use in some equation and working that down so you can figure out what site parameters someone is going to need.

To help you figure this out you must make the determination, set the parameters, and then you're going to need to calculate the performance measurements.

So, Step 5 is to determine site parameters and models needed to calculate performance measures.

Now, we're down to Step 6. Select appropriate suite of field and laboratory tests to acquire site information.

Finally, very important, is to prepare the study plans and technical and quality assurance procedures necessary to implement the site program.

So, now you can get an example on the hierarchy, if you will, that you'll find in there.

Example for one was getting a performance parameter. This is one level now from the performance measurements, which is really the way your going to reflect the site or the engineered barriers.

Performance parameter is the annual probability of volcanic eruption that penetrates the repository.

The first level of parameters that are defined by the working group--bear in mind that these types to be set up requires not only just the site characterizations, but people who know what kind of measurements they will have to make in order to present evidence of magma bodies in the vicinity of the site but also the people that are thinking about what kind of calculations they're going to have to make in order to evaluate the compliance with the regulations.

If this thing is going to serve you, you must have a real mix of many calculations, engineer calculations, many types of people, the site data acquisitions, all working together, all figuring what kind of site data is needed.

So, if we look at the site parameters to be provided; namely, the location and timing of volcanic events, evaluation of structural controls on volcanism, and the presence of magma bodies in the vicinity of the site--I may not have listed the complete list. You can see for yourself. Volcanism drillholes; geochronology studies; geochem, scoria sequences; location/timing volcanic events; geochem cycles in basalt fields; subsurface geometry quaternary faults; evaluation of depth of curie temp. isoth, and heat flow.

These are actually the titles of each plan. You'll see most of them in the back of the hand-out for you.

Most of them are at this level of information so within that study plan there might be a whole level that gives you all the alternative ways of getting at that information.

What kind of site data would you get for geochronology that were provided in that one study, or were listed as they might be provided as part of that study, and you can see the sort of things that Bruce talked about; the Helium 3; K-Ar Ages; U-Th disequilibrium measurements; cosmogonic He-3; cosmogonic C1-36; cation element ratios, desert varnish; paleomagnetic pole position; scoria cone and lava flow geomorphic parameters, and soil development parameter.

I'm giving you a glimpse. You want to understand what kind of site data acquisition plans we have.

What you have to do is sort of start over with the requirements and work over to the right and end up with the long list of parameters that will be provided by one of these study plans that services it.

Like I said earlier, bear in mind that some of the data is not that specific because we also have to make sure that the program covers a credible development of the conceptual models.

We chose one other example for you for the unsaturated zone geohydrology program.

The performance parameter is fluid flux and you work your way to the right in the site parameters to be provided.

What you come up with is flux all the way through the Topopah Spring welded unit.

You obviously don't go out and measure that.

What kind of studies or activities go into determining a value for that particular quantity there? Surficial materials, and natural infiltration we will highlighted a little later. Some artificial infiltration.

To better understand the surface infiltration on flux at the repository we have chlorine, 36 studies; intact fracture studies.

Take one of those again. I think you're getting the idea. You blow this up and you end up with the long list of the actual measurements.

Some of these problems still do not have the measurements in order to actually provide this type of information back into the system to the user.

The other thing we're putting in here to impress you--the NRC are certainly going to give us this feedback, as well as anybody else who looks at it.

It's laid out in such a way that you really have to take your time and work your way through it to really evaluate whether our plan is comprehensive, whether it's likely to be adequate.

The idea that your going to collect any information, and, at any time, something needs to be changed, you go back into the plans and you revise it to include any new information that was missed or overlooked.

So, in terms of the kind of uncertainty--and this is a step back from the details- you say what kind of uncertainty are we looking for.

We talked about this, and I thought several people brought it up, and thought it was a nice way to display the ideas.

You clearly have some uncertainty in parameter values. You need that uncertainty in frequencies. The uncertainty you have in final calculations say of travel time so there is this whole translation, if you will, of the uncertainty of the measurements through to the calculations and that's going to be extremely important over the years. Uncertainty in our site models. Clearly we've heard that and you heard it demonstrated in the last two days.

I think you heard with the State Staff yesterday that there are places where I differ a little bit from the unsaturated zone that the DOE has so we certainly have some specifications.

I think they go hand in hand, uncertainty, due to extrapolation of models.

We need to understand in many cases--this will be important in the very near future when we're predicting engineer barriers-- what happens when we're even with accelerated testing maybe 6 years or 8 years, with some types of data but not from this unsaturated condition for many years, so how do you gain confidence that your exploration is picking up all the data so that your extrapolations will be credible and you'll have high confidence in them.

Down to the other one. Uncertainties due to unanticipated processes or events. We don't really mean we unanticipated-- it's a low probability but potentially high event during the 10,000 year period that we have to worry about from a regulatory perspective.

We have four diagram illustrations to give you an idea of the overall uncertainty patterns that we're thinking about when we put that together and this is a nice break so you don't have to look at words.

Uncertainty in parameters, you need to know what the overall distribution is for any given parameter.

You've heard already from Bill Wilson about the flow process, how important it's going to be when we are in condition of making some fracture flow and what controls that; that's clearly one of the things that we will review.

Later we will pose the question of unanticipated events; our approaches to looking at hazards related to unanticipated events such as major faults--faults, especially unanticipated might be from the discussions a fault, a large magnitude on a fault that we don't have any evidence of right now. Either it's not expressed at the surface or, if it does, it doesn't look like it's had recent movement.

That probably gets us right in the lower probability but potential high consequence and then extrapolation of miles.

I heard the discussions about the kind of prediction that you have to make in the crossing of materials and always being concerned if you go just a little bit longer you might pick up a different procedure so that's the reason that I always use as my example on this one.

What are we going to do in general since we're going to use multiple approaches? Whatever problems are credible and make sense, we will obtain values for the key parameters.

You'll see in a second about the sampling program that we use to set up. We use any kind of statistical that we can apply to help us select sample locations and to make measurements at different scales any time we can, and, of course, we have the opportunity to do small diameter examination of cores and all are experimental.

As far as the site modeling goes, we set up a way of looking at uncertainties at site models.

See this display. If you look at this characterization plan, every site program, where it made sense to do it, we have something that's called a hypothesis testing table.

It explicately identifies what our current model is and makes a quality assessment. It can explicately be used on our alternative models.

Then we look at the significance of the uncertainty in either the current or the alternative models.

You'll understand if there is no significance and significance equates with impact on performance.

If there is no significance, be it maybe something that just doesn't have much to apply to performance, or you may not need for design so you do not need to focus your testing program on that.

Then what you hope to do is to collect the information to reduce the uncertainty in the current model or in the alternative model that has been laid out which has the greatest potential for significant impacting on performance.

This one is just an example in your materials. In fact, this one Dave Dobson brought for you in words instead of the summary where it displays the hypothesis for the faulting mechanism that we displayed that you saw in several of the presentations.

Alright. We're at the point where we're going to the specifications of the testing program and so before we do that, let's talk about what the overall strategy is.

We have some loops in there and some kind of a simple way of looking at those loops.

We've told you we took the regulatory requirements, which clearly is some kind of information that we're gathering through the site program.

We took our current site description that we have for hydrology and for the tectonics at the site and attempted to focus the testing program to respond to the models that were defined that were most important in meeting the regulatory requirements.

We will then hopefully go through a period of investigations and then we'll come to a point in any given area where we'll ask a question--

If we gather information that causes us to change something about our site directions--we got parameter values that were way different than expected--some type of information that makes us think that an alternative model needs to be added, we will then add that to our list.

This is the point where you make that decision and go through a refocus and if you said yes, you go back perhaps to the models, make some revisions and come back.

If you said no at that point, then you still go through a question of, do I have adequate confidence and this is, of course, the million dollar question.

What is adequate confidence going to be when you're talking about a

10,000 year prediction. How will we answer this question? Well, you probably have some ideas. We all do. It's not going to be one person to proceed.

If the answer was yes, then you go into the regulatory and see how you did. That would be a way of looking at it.

If you said no, then you're going to have to go back and say, well, I've done everything and I even perhaps had to go back and make some changes in my models but I've now come back to a point at some alternative test capability.

If you asked that question and found out that your overall testing program--you just about exhausted your probability and you came up here, is there any strategy that makes sense?

If that answer is no, you would then have to really take a hard look at the feasibility to proceed at the site.

If the answer was yes, go back into the loop.

This is in the site characterization plan and in one or another variety. It gives you the idea of the thought process that's laid out in the SCP.

Rather than just rolling into the study plan story and the story of the program, this morning when Max was talking to you a little bit about the question of whether we're in fact going to go into the Calico Hills--you won't find this in your package and you'll just have to tune in for a minute to the screen.

Nothing complicated being presented but just the idea that he asked me to give you a little more information on the thoughts we had about this risk benefit assessment for penetration of the Calico Hills with the large diameter shaft and so I've thrown in a couple of graphs here. If you want copies, we can get them.

As Max said of NRC, between the consultation draft and the final plan, NRC made a decision to defer making a decision on penetration with the large shaft and they're using this risk of sorts and that's one of the things we wanted to tell you about.

We're going to look at the need for the information from the Calico Hills.

The SCP made it very clear. They're obtaining information through the program but what about the large exploratory shaft? What alternate means do we have?

Outcrop samples, surface- based drill, small diameter drilling from ESP are extending the exploratory shaft.

We'll look at the benefits of obtaining the data. What kinds of risk do you have if you open up a shaft into Calico Hills and particularly if you also extend up a fairly large volume of that rock to look at it.

Well, you need to characterize it. Is there some chance you might compromise it's way to perform.

We have a plan that's been put together and it's in draft form so it's not quite ready for the group to proceed but we will, in the next couple of months, intend to have the plan approved and to get on with this analysis.

In this case, our benefits on the technical side have something to do with the improvement of confidence in predictions of site performance of the Calico Hills.

That barrier that we set that program with, are we going to rely on that for travel time? What's the site?

They also have to look at benefits from the standpoint of the program, meeting milestones, and obtaining the needed data in a timely and cost efficient manner mutually by a programmatic method of putting the shaft on the current plan or the plan that we have had prior to issuing the consultation draft.

That might be one reason to go forward on that but clearly the risk involved would be potential for impacting the performance of Calico Hills by opening up these excavations and programmatic.

If you don't go ahead with it, you may have schedule delays and higher costs especially if it ended up later on that you need to go in to it so there's a lot to be looked at in terms of the risk and benefits and it's where you're heading, the overall confidence in your prediction of performance and how confident you're going to have to be.

Well, obviously the technical risk will be to look at the potential effects on water flow paths through the unsaturated zone, any effects on moisture content of the unsaturated zone, and one other one that has been suggested is, as you look at the thermopile, what impact would there be if you do have the shaft opened up in the Calico Hills. How would that impact the temperature effects in the Calico Hills?

DR. WILLIAMS: How would we do it?

It seems to me, if you can't handle doing that, I don't see how you can handle the analysis for the whole repository.

There shouldn't be any risk.

DR. YOUNKER: In the whole argument of risk benefit and in listening to the people, it almost comes down to a position where I've heard this expressed by some of our people who kind of wonder if our models of the unsaturated zone are close to being correct and clearly we already know the answer to this question.

DR. WILLIAMS: I would think so.

DR. YOUNKER: On the other hand--

DR. WILLIAMS: --if they're correct.

Just tell me how they're going to evaluate the risk.

DR. YOUNKER: Well, I assume that what we're going to have to do is to look at some kind of an estimate of what the probability is.

That large shaft could act as a short circuit. From a technical standpoint, I think that would have to be looked at.

From a regulatory view point, I think for travel time, we would have to start at the base of the shaft in the Calico Hills, and, therefore, shortening the unsaturated zone section through which we conduct our travel time so that's a technical and regulatory view.

Now, on how we might do that, if you would want a more in depth technical side, I suspect someone--

DR. NORTH: Can you give us an example where you tried to deal with the risks and benefits of a change in strategy and work out the contingency as to whether or not you should make this variation in the general plan?

I think it would help us in getting an idea on just how difficult this is in your environment to go through and consider a change in the plan.

DR. YOUNKER: I can take a crack at it.

I think it's all a matter of priority and how much effort from the key staff that we need to put on this particular problem.

I don't think that our procedures, the approach that we're going to use to make this evaluation would be a limiting factor.

I think we estimate in the plan something like a total of a 6 month duration of the analysis and the study and the presentation of a final record or a final paper from the group that works it so I don't think it's a terribly long evaluation.

Now, that's using an established procedure to quality level one. Did that help?

DR. NORTH: How far are you from the 6 months?

DR. YOUNKER: I think we started the plan in about February so the plan is in the draft--

DR. NORTH: So when we have our meeting in September, you will be ready to show it to us?

DR. GERTZ: We'll get back to you but your question is well taken.

Changes like this in the program, you need time to show that you have taken everything into consideration and time to implement them, once a decision is made, and then we have to implement it, so it doesn't come easy.

DR. YOUNKER: The contingency for extending the shaft is being maintained in the plant so there won't be a need to go back in any major changes in the design plan.

Of course, we will have to establish what kind of testing we'll do in the Calico Hills and I think many people would probably say that we already are planning to go into Topopah Spring.

There is a little more peculation, if you like that.

DR. WILLIAMS: I'll talk to them afterwards.

DR. YOUNKER: What we're going to do is give you a real quick presentation from the standpoint of activities that we have planned and tomorrow you'll get a really nice overview, I think, of the example of these or a chance to talk to people who are involved in the development of the study programs.

I'll tell you in just a minute--we have a different way of looking at the drilling program. We're going to make sure that you get any information or any positions structurally or otherwise that you think you need to have information in order to make sure that we have extensive geological mapping.

A pretty broad set of geophysical studies are planned, both site specification and regionally. You've heard some discussions already about the question of--we'll give you a little bit of geophysics.

Some remote sensing. Probably not a big emphasis on remote sensing.

Some of the trenching studies and laboratory studies that support a lot of the field work.

In your diagram that you have is simply a summary of the plan site activities and hopefully you can see enough of this to at least see the drilling, the boreholes that have the large paths or the one's with the plus signs in the middle of the rectangle.

We have pretty good distribution of trenches. I think the triangles were the trenches. I think the triangles are trenches and the rectangles are the large pad drillholes and probably circles are the drillholes.

This is just kind of for reference. We may come back if specific questions come up.

Of course, this is the complex right here.

You've heard of prototype studies a couple of times. We have some studies on developing instrumentation methods.

We also have some G-tunnel and surface studies.

One of the things that has come up several times in our discussions is the question of the requirements.

Just for you we put this diagram so you can get an idea on the way the DOE is looking.

In the diagram, SCP laid out for you the requirements for dry core. We don't say we require dry core. We clearly have an approach that's based on prudency.

It would be nice if we could dry core because we don't have to worry quite as much as to the effects the drilling fluid have on the samples we're obtaining but, as you heard, if you did dry coring, you have to worry about drying out samples.

If the program for prototype dry coring that you're going to hear about in a lot of detail, if we are successful, then clearly we think we can go in the direction of a pretty complete drilling program with as much core as we need with dry core.

If we're not successful in this early prototype--and I think right now the results look pretty good, then we might go back and do our analysis requirements because one possibility is that you can do some drillholes and go with an analysis at the cutting but the hydrologic people will agree that some of the analyses are some of the parameters that they need.

They don't need a full large core sample but they can get by with cuts that the dry core approach might be able to provide.

We also might--depending on the outcome here--we might want to look at the moisture control because it may turn out, because our balanced approach will be depending on the prototype, with some dry holes using prior cuttings from them and a little bit more of fluids to get some better core retrieval.

We could always look here. If you weren't successful, now, you might want to keep trying so you might look at some other techniques and clearly you always have to.

We're not going to look at it any more but from what Carl told you this morning, the dry coring techniques so far are looking pretty hopeful.

Let's look at the overall distribution plans for the drilling program.

These are the first set of preliminary drillholes that we've processed. It gives you the diameters and the depths.

I think you can see a couple of them that I'm going to focus on.

The first being the systematic drilling program but this is for your reference in case you're interested in what kind of diameters and depths are used.

DR. DOMENICO: I'm interested in the shallow unsaturated zone.

DR. YOUNKER: These are shallow infiltration studies.

DR. DOMENICO: I thought they were drillholes.

DR. YOUNKER: They're 300 feet.

DR. BLANCHARD: No, 500 feet.

DR. DOMENICO: This is outside of the repository but on Yucca Mountain?

DR. YOUNKER: Yes, and if you go back to that other diagram, you can probably--

DR. DOMENICO: No, that's alright.

DR. BLANCHARD: Just to make sure there's no confusion, those that are penetrating within the repository boundary are going through the Calico Hills, into and through, like I mentioned this morning.

The unsaturated holes and the systematic drillholes within the repository boundary are penetrating the Calico Hills so you measure it on the Calico Hills.

DR. DOMENICO: That's also on Yucca Mountain?

DR. BLANCHARD: And those are outside too.

The question, it places a limitation on the layout of the repository because the regulations require that once you do that, then you have to have the holes inside and passed on our analysis for the repository. That is two different situations.

What we think right now is a desirable distance between a drift and a hole. Every time we put a hole in, whether it's a systematic drilling hole, if it goes down to the Calico Hills, then it will have a large pillar down it.

DR. DOMENICO: Is this to accommodate 7,000 metric tons of heavy metal?

DR. BLANCHARD: Yes.

DR. DOMENICO: So you will not have to increase the site later?

DR. WILLIAMS: All of those holes are part of the systematic and it combines and all of those holes are expected to penetrate through Calico Hills' water table, actually 100 meters into the water table, so you can see water table holes are out of the repository.

This was designed with the repository in mind and for future expansion of the repository so that it can extend to the southeast part of the repository without interference from those holes on the current design on where the pillars would be located.

DR. YOUNKER: This is for the systematic drilling program.

Approximately the uniform areal coverage of the site within the conceptual repository boundary with effective borehole spacing of about 3,000 feet.

It was based on correlation length for basic physical properties.

This then gives you a number, which we put in the plan that's something like 87 percent of the area within the conceptual repository boundary, and at any given point you will be less than 1,500 feet from a borehole.

We want to look at systematic view points as well as the cluster of boreholes that Allan mentioned that was down here in the southeast part of the picture.

We want to be able to compare the availability that you get from systematic samples versus the ones that are clustered and so we'll have the same amount from the systematic approach and the future sampling.

I think I'll tell you about it on the next graph.

Obviously, when you go with this kind of approach, your just trying to get an overall availability that you need to use in your model.

In our contingency, this clearly is the kind of thing you want to do.

Once you get a certain amount of information, you want to look at the availability and then determine if you need to do an additional phase of drilling by looking at what kind of uncertainty you get if you go with another set of four or six, whatever number, of drillholes so this gets at that whole question of how much will be enough; what distribution of samples will it take to convince us that we understand that rock well enough to make the kind of predictions that we need to make.

The other sampling program for boreholes are tests to test specific hypothesis about anomalous behavior or conditions.

Locations are generally selected to investigate structure/feature of interest such as Solitario Canyon Fault, Ghost Dance Fault, and one that came up which Bill certainly talked about and that's about gradient in the water table.

DR. WILLIAMS: How do you investigate that? How do you do it?

DR. YOUNKER: Where there's a horizontal drillhole.

DR. WILLIAMS: Is this still a surface-based program?

DR. YOUNKER: That's right.

DR. WILLIAMS: From the side? I don't understand.

DR. YOUNKER: It's from the west side and I don't recall the depth. It's slanted a little bit down but it's basically a horizontal hole coming in.

Obviously, this hole is a credible hole, given the current data, because we want to evaluate the alternate models.

Now, our goal is to ensure that data are adequate to evaluate alternative site models and determine their potential impacts on site performance.

I think the Solitario Canyon is one of them.

From the unsaturated zone, clearly these are very general for you.

Our studies must determine movement of liquid water down to the water table and water vapor and air within the unsaturated zone.

Tomorrow I think you will get a change from prototype studies and understand some of the approaches that we're going to try to use to gather this kind of information.

We must determine effective hydraulic conductivity, storage properties, and transport properties as functions of moisture content.

There's a couple of different things you'll hear tomorrow that we're going to look at.

Another major focus is at Fortymile Wash to determine that as a source of recharge to the saturated zone under present and past conditions.

I think you've heard from Bill Dudley's presentation the potential that

Fortymile Wash has in the stability of the water table.

If you look at the saturated zone studies, there's multiple well interference testing to obtain improved estimates of hydraulic conductivity and storage coefficient.

Tracer studies to investigate directional characteristics of hydraulic and transport properties including drift-pumpback tests and 2-well recirculating tests.

Most of these tests are at the level of these 106 studies that you heard mentioned where one particular study may describe this set of tracer tests that are going to be conducted so I'm trying to give you a flavor of what the--I know some of you guys have an impression.

The study plans are not totally uniform. Some have a number of activities and some have a fairly unique focus on one specific activity.

This kind gives you an idea on the drift-pumpback tests and 2-well recirculating tests. These are getting outside my area.

Pumping tests are to establish if Solitario Canyon Fault acts as barrier to eastward movement of ground water.

That was that horizontal hole I just mentioned.

DR. DOMENICO: In the stating of these tests, would you be finished with the unsaturated zone before you put an exploratory shaft? Is that a factor?

DR. YOUNKER: It's surface-based testing.

DR. DOMENICO: Really water and testing for water. That's an issue.

DR. YOUNKER: I think that certainly has been looked at and we're looking more at the surface- base program in terms of it's potential for interfering with other testing.

DR. DOMENICO: Why don't you do a risk assessment?

DR. YOUNKER: We are now. I think the idea was to lay out a comprehensive program that would get you as far as you can get in the amount of time rather than phase it in that way.

I was trying to walk you through just to give you a flavor.

We'll look at the highlights from the geologic mapping activities.

Now, surficial materials to be mapped at 1:12,000 to delineate units with common shallow infiltration and runoff properties.

There are certain 1:12,000 mapping of zonal features in outcrops/pavements of the Paintbrush Tuff formation as basis for developing understanding of 3-D fracture networks.

So, now we get a better basis for getting an understanding of three dimensional fracture networks, which is important from the standpoint of looking.

Now, from the monitoring activities, just a selection for you so you get a preview of the kind of questions you can ask tomorrow.

Neutron moisture logging used to detect changes in water-content profiles as evidence of infiltration events in the shallow unsaturated zone.

This is the program you asked us about when you thought you were asking about a different program. Most of them are aimed at this infiltration study.

Tritium profiling studies. Use bomb produced tritium concentrations in core from neutron access holes to determine flow velocities over the past 30 years.

It's kind of a nice natural laboratory set up for us. Also a fair number of instrumentation that is set up that will allow us to get out some of the parameters that are, of course, important for understanding and characterizing the unsaturated zone.

Sensors--pressure transducers, thermocouple psychrometers, heat dissipation probes, thermal sensors--are installed in unsaturated zone drillholes, monitor pneumatic potential, water potential, matrix potential and thermal potential for combined matrix/fracture system.

You'll see that in a couple of your presentations tomorrow.

Continuous water level monitoring, interpret short term water level fluctuations, for example, barometric, earth tides, seismic events, and nearby pumping.

Hopefully, the view that you will get from this is that you have a pretty comprehensive program in the areas of high characterization and geophysical activities.

I pulled out what is probably a third on the list of geophysical activities that we have.

We have in the plan a lot of studies, I think, that are to look at lithophysal zones, to try and get at the 3-D fracture network plan, of course, but in some cases we have feasibility studies before a lot of money is committed, we will take that technique, do a feasibility study and then go ahead with the study after that decision is made or is passed.

Gravity survey, 1:24,000, scale map of site to be constructed from gravity observations--station spacings equal 200 feet, east, west lines spaced 500 feet apart--to infer fault locations and continuity of rock units.

Aeromagnetic survey, 1:12,000 scale map of site to be constructed from east, west flight lines space 1/16 miles apart to infer fault locations and continuity of rock units.

Stress field. Hydrofrac measurements and analysis of borehole breakouts in 4 boreholes--six to ten intervals within each well-- to evaluate vertical and lateral variation in present stress field.

This stress field area is another area where there's problems with the techniques. We'll probably have multiple approaches to try to get at the stress field.

Trenching, you've heard about Jerry King, and he showed you some maps, which is one of our earlier trenching programs that will be getting started.

We'll look over the potential movement on the faults in the region looking both at the magnitude and frequency movement, also some trenching where we can look at marsh, lake, and playa deposits, and there are perhaps in these--I don't think I put them in your packages--our proposal for these kind of trench studies.

Laboratory studies. You'll be hearing about this tomorrow.

I picked a couple examples for you.

Radionuclide, batch sorption measurements as a function of solid phase composition, sorbing element composition, and ground water composition.

Experiments to determine effective retardation by dispersive, diffusive and advective processes in matrix of each rock unit in saturated and unsaturated zones.

Mechanical properties of intact rock. Determine effects of variable environmental conditions--sample size, strain rate, temperature, confining pressure lithophysal content, and saturation.

From the standpoint of mechanical properties, I'll skip over these because you'll hear about it tomorrow.

Let me emphasize this one because you won't hear this tomorrow.

One of the important areas, we have to look at what's the environment going to look like so we have to identify and characterize the reaction products formed during rock water interactions at elevated temperatures.

We must determine effects of container and borehole liner corrosion products on water chemistry.

You have to look at what unnatural materials you are adding to the natural system and what effect that will have on the water chemistry.

Obviously, how the water behaves, how it interacts with the rock material depends on what it takes with it when it leaves so we have to understand that so we can really make a credible provision.

We must establish effects of repository induced heating on hydrologic properties, effects of dehydration-rehydration, potential for convection and heat pipe effects.

The potential for dehydration of any of the minerals that are close enough to the water where the temperatures reach say the boiling point of water are getting up to the point of instability.

I think tomorrow you'll hear about that also, to lay out where the temperature profiles are in the Calico Hills, given our current understanding of the voice loading that we use so you'll get a three dimensional sense.

We'll try to reach down in the zone. There's been concern in the past and certainly still necessary to be looked at any potential for changing that very near field with properties that you'll promote to be incorrect.

DR. LANGMUIR: If someone from the DOE program that we've already discussed by the state about the zone work where you were looking at the creation of a cemented zone--

DR. YOUNKER: As I recall, part of this study went into the hole of precipitation and dissolution during this phase and the potential, with the heat pipe effect, has to do with some sedimentation and moving minerals around.

Giving the lateness of the hour, I will really not cover the exploratory shaft but I will just give you this introduction that clearly we have a lot of systematic mapping and sampling planned.

We have an opportunity to investigate processes and conditions in the unsaturated zone as well as conduct controlled simulations.

We want to look on the effects and this is part of it that's really important, the effects on construction techniques. We will start to get in to more of the design side of the effects.

We can look at near-fields and drift-scale heating effects in the host rock.

In these areas many times the more important thing is to make the calculation but we have reasonably good models already.

We must get out and do the tests and get to large scales and be able to get parameter values for large scales.

It's just a nice diagram. I think you've seen it before. It is a whole list of all the various types of activities that are planned during the construction of the exploratory shaft and a whole list of tests that will be conducted.

DR. WILLIAMS: Before you leave that site, you have 50 to 60 radial boreholes of short and long southeast which means they'll miss the testing at the Ghost Dance Fault? How come you don't want to test them?

DR. YOUNKER: I'm going to ask someone else to answer that.

DR. GERTZ: It is a long distance away.

DR. WILLIAMS: I'm sorry but I don't see any other way in the whole project of testing it.

DR. GERTZ: Other than your exploratory drilling through it.

DR. WILLIAMS: You don't have any experiments.

DR. GERTZ: There's experiments.

DR. YOUNKER: I think the plans for characterizing it are set up. They are very broad and yet at this point--

DR. GERTZ: The west of the site is to look at the Ghost Dance Fault. That's our purpose.

DR. WILLIAMS: I'm sorry. I didn't know it was a long history of debate on the subject.

CHAIRMAN DEERE: We are restraining ourselves.

DR. YOUNKER: That is one of our important studies from the bottom of the exploratory shaft, as it is now explained and Carl was just talking about and this and the next few graphs will allow you to see the layout.

One is to take us to that fault zone which is to the east of the zone.

Put up the next one and I'll talk about this.

This gives you a nice idea of where those drifts are expected to go and this is the actual current design of the exploratory shaft showing the location of the drifts as well as the fault.

These are the precise locations as best we have them going over to the fault up to Drillhole Wash to look at that structure. If there's a fault, characterize it and go over to the Ghost Dance Fault, which is shown here.

As far as the testing, I'm pretty sure what we intend to do is develop those plans much further and study the study plans. They'll have to be some detail descriptions on the type of plans we're going to do.

DR. WILLIAMS: I didn't even see that. I'm sorry. I just missed it.

DR. YOUNKER: The rest of this page, now that we have it up, is what we put together to give you a complete list of all of the studies that are currently planned.

Now, each of these studies, in some cases they're big amounts of work and in some cases they have one major activity so if you go by the title, what I did was put them together.

It's an interesting way to look at them and it allows you to get a feeling of the way the program is laid out.

If you look at those that characterizes the natural barrier, you'll see pre-waste emplacement ground water travel time so you don't see any interrupted scenarios there.

The unanticipated events in that terminology where the total system performance is where you see all the studies .

Studies are focused on site information needed for predicting performance of engineered barriers.

Here, once again, because of the way the regulations are written, this is just for the format or the nondescriptive scenario.

Finally, studies focused on preclosure and postclosure facility designs.

Now, here's another long list of studies that focus primarily on the underground facility, the surface facility.

What you see here, when you go through this list and go to the first page -- well, the idea is that you see a long list and the sections you see here correspond to both the studies and the number of the study plan, which is how we keep track of them where you can find a description of that study.

For example, if we look at 8.3.1.2.2.8., fluid flow in unsaturated fractured rock. You see a complete range from analysis assessments back to the actual description of the techniques you're going to use.

There's a wide range here but they all are laid out.

If you go one level, there's a whole set of activities defined that will allow you to look at what the picture looks like.

In many cases, for example, the geochemical, all of our stability minerals play an important role in that work and I've placed under the total system, release characterizations.

The next one is waste package performance. You'll see that the bottom four study plans list all the characterizations and any logical changes in the post emplacement environment.

Also an important preamble performance is what kind of flux or they going to have to deal with. Also they need to understand what the rock properties are in order to do the kind of modeling that needs to be done for predicting how these changes occur during the period.

Seal performance, look at the different materials, look at the properties of those materials for the use of seals and finally the last one, which is a very long list, partly because our program is broken down to a lot of small studies.

Probably the last couple of pages is going into tectonic studies.

If you go--just as an example. This doesn't prove anything to you. I wanted to mention the way the program is set up, although we have a lot of understanding about seismicity at the surface facility.

In the location of the underground facility, we also have a study and several studies here looking at the variable faulting within 100 kilometers.

This gives you an idea of the range of studies. It's very difficult to know how to get you a survey in a short time with the kinds of plans that we put together but hopefully with this and with tomorrow's presentation from some of the team that are in the audience.

Thank you very much.

DR. ALLEN: This uncertainty, isn't it equally likely on a number of these studies?

I'm reminded, in a similar sense, of California along the San Andreas Fault, as to predict the next earthquake. I think we have to recognize the fact that it's not necessarily true that we're going to reduce the uncertainty.

DR. YOUNKER: I know several people in this room have had this conversation.

We were in fact betting how the plot would go.

Certainly, for the first bit of characterization, you know that the uncertainty is going to go up. They're all going to be going through all ideas. Hopefully, in those areas where it matters--I won't take this to far--but in those areas where it really matters from the standpoint of performance, we're going to have to bound our uncertainty well enough that we can face the regulations that we have to comply with.

CHAIRMAN DEERE: Isn't it true that when we increase our sphere of knowledge, we increase our contact with the unknown?

DR. BLANCHARD: In order to close it off-- I realize a lot of people aren't enthused at looking at a 6,000 page document but we don't have some handy tools or aid for those people that are interested.

This document explains by map, by topic, what we have done to the site.

We also have a multi-volume document which is called Surface-base Investigations, which has some of the larger scale maps that are shown up there.

One of these volumes takes every single type of activity that the plan has and draws a map for it and labels what's where so if you want to follow what's planned and you don't want to go through the SCP--

A copy of this volume has this handy little fold-out about this size which characterizes every step and, as we do this work, it transfers into this.

Now, Carl wanted to touch on the summary and after the summary, what we'd like to do is talk you through and introduce you with some of the speakers on the field trip and explain what will be done and arrange for that.

DR. GERTZ: Let me go first. I want to clear up a discussion which was very poignant because it was an element of my presentation that I failed when I failed to notice of some of the interactions with the Board.

I talked about drill and mucking machines and we're preparing a report both on that and the additional exploratory shaft, so we're working on it.

This happens to be just our current position. It may or may not change, depending on future studies.

The second thing I wanted to point out was about a comment, that when we talked about existing core, and I had a comment from a member of the Board, we have about 37,000 feet of existing core that is in the archives, so to speak.

You're going to get a good opportunity to see that tomorrow, that core.

The state can not be used for licensing information. Very simply it wasn't obtained under a program, which is NRC. It lays out procedures that, if we want to use that core, we have to go through a process either through having a lot of correlating data, having some data, or any kind of combination of those items so if we have a core that we need to use, we're going to have to lay out a process to use it.

None of it can be used for licensing data. That's not to say that's not been used. It was obtained with good state-of-art scientific procedures at the time.

As I said, when we get in Court for licensing activity, we follow different rules. I want to set that out so when you see the core, you know what it is.

Some people gave me estimates, it's added 50 percent to the program. It's hard to tell. Who knows what the numbers are but the question, it's a requirement.

I want to put out much, like we talked yesterday with the State.

You heard us talk throughout all of our presentations. We need to gather information. That's our whole goal in the next 5 to 7 years. We have to go out and gather information and when we get that information, it will present some dilemma's for us.

We have some major technical characterizations that are going to require resolutions.

After we achieve consensus, we're going to have to develop models and consensus on those models.

We have a lot of channels. It's not without changes but the only way we can address these changes is by started to gather data and expand some of the areas of uncertainty and that's really my closing remarks.

We will really approach the opportunity today to talk to you about the program and certainly hope to expand our discussions with you tomorrow and I'll answer any questions.

DR. LANGMUIR: You and I talked about this turn-around of data in maximum of 45 days to get from the field out to interesting parties and you and I both know that can't be done.

I'd like to hear what your policy is going to be to make that plan work.

DR. GERTZ: Well, I think it can be done. All these complex tests are going to be done by scientists and documented so it can be used in the licensing activities and, I believe, the 45 day requirement can be met.

It will document--and it's checked by the quality assurance but the responsibility for quality assurance rests with the line people. It rests with the scientists. We don't put the responsibility to quality assurance.

They just check that we are doing our job and if we do our job properly, I believe we can meet those 45 days and that's a challenge we laid out.

We talked in depth about this. I think they'll be able to achieve it. It's going to be tough at first until we learn how to do it but we're heading for that.

I hope I can tell you we got some of them out in 45 days.

DR. BLANCHARD: Some of the things we do is monitor. We monitor the water level. We monitor seismic activity. These things are very amiable to periodic sampling. Putting the date into the record by the proper quality assurance who checks on it, and sampling the package and distributing it to those who want copies of it.

Another thing particularly in the laboratory where you're running a test for 90 days before you can assess whether you have any corrosion on waste package material, it wouldn't make sense to disrupt that kind of test, so we have to use a little bit of common sense and decide what type of test it makes sense to report on-going results every 45 days and which type of tests where you really wouldn't have a sense of understanding what that test was producing until you went through one cycle so we will be looking at those test by test to decide which would be the best cycle in cases where 45 days would not make sense. DR. LANGMUIR: How do you deal with the scientists and their wants to explain them and defend them and define their meaning?

DR. BLANCHARD: That's the difficult part because this process will provide the data for whoever wanted to start analyzing it, perhaps, at the same rate as the scientists who created the test and created the study plan.

It's an interesting question you asked.

Just to close off, I want to pick up on a few things as we start on our discussion about our field trip.

We're moving 70 to 100 people around in the field and it took a fair amount of planning and I hope that we don't end up with a serious breakdown or mishap in terms of scheduling.

The busses will be leaving at 6 in the morning. At approximately 6:40, they will leave Mercury to come back here at St. Tropez about 8 tomorrow night.

Once in Mercury, there will be vans that will provide transportation from Mercury to the Yucca Mountain area.

The occupants of the first 3 vans, which is basically the Review Board, should be badged at Mercury first before anyone else.

It takes a fair amount of time to get through the badging process. You can't get into the Test Site without the badges, and photo I. D.'s will be required. This is like our driver's license for all visitors that are allowed on the Test Site.

No cameras or recorders are allowed.

Try to think much about personal comfort. It's hot out there. It could be over 110 degrees tomorrow. It will be very sunny.

If it's real hot, the wind will be blowing a lot at the high points on Yucca Mountain.

Wear light clothing, have a shade hat because there are no trees out there. Use sunscreen.

We're going to have 2 pick-up trucks with ice, water, and soda so you won't get dehydrated and please, by all means, actively pursue what's in those ice chests because we don't want you to dehydrate.

Everyone knows the way. Don and Bill and I have worked to separate the van assignments. We have in each van Board members, some DOE staff, and some State or some NRC or someone from the Senate.

The list of persons are shown here.

Once again, please get in line to get your badge and move into your van as quickly as you can because it may take 30 minutes or more to get the entire group through the badging.

Are there any questions?

Now, for the vans, I would like to introduce your drivers and your escort. The DOE escort--and you can not wander off from the escort or from the van. Very serious things can happen to you, if you did. They come out of the sky with weapons.

The process, as I mentioned, is to board the bus here. We'll be at the site around 7:30. We're only allowing about 15 minutes for the first 3 vans to get their badges so please move along fast.

The drive to Yucca Mountain will take an hour. We'll go to stop one, which is the top of the mountain. We'll have geological briefings from about 9:00 to 10:20.

Then we'll have a hydrologist briefing from 10:20 to lunch time.

We're allowing about 30 minutes for lunch, maybe 40 minutes. You may eat much faster than you think. It's uncomfortable so you might be able to finish sooner.

You will get at least 3 drinks per person for sodas.

THE WITNESS: There are about 15 or 16 cases of soft drinks. I don't know, about 30 or 40 gallons of Gatorade, and an equal amount of water.

DR. BLANCHARD: I don't think we'll run out of liquids.

Then after lunch we'll go to Trench 14 and we'll stop there and talk about hydrogenic deposits.

Then we'll walk up to Exile Hill and have a discussion by Jackson describing the trench facilities and then we'll return to the vans and then we'll move to the ESF location and a briefing on the layout and then we'll have a briefing on fluid potential and then a discussion on resistivity and then we'll move over to Stop 4, where they'll be allowed a good view of Ghost Dance Fault.

We'll move over to the sample management facility and we will start with a briefing and then we'll have a discussion.

They'll have a core layout and examine what some of the characterizations are like, and they will discuss the mineralogy of the core samples.

We'll then have a briefing on some of the rock characterizations and then a briefing on the program, on the dry drilling program, and we expect to be boarding the vans right about 6:10.

We might get a little backed up here. We'll try to have the Board go through this and so we'll do some of these in parallel in an attempt to finish by 6:10.

Now, a little bit with respect to hand-outs, there's a package for everyone who wants one for tomorrow.

We have a special briefing package for the Board members and the group in vans , 2, and 3.

Let me talk you through this.

CHAIRMAN DEERE: I didn't see any rest stops.

DR. BLANCHARD: We will go and ask about portapotties. There are no trees and it's a long walk to the nearest canyon. We have portapotties.

These are some things that you might want to do to get prepared for the trip tomorrow.

We have a booklet on the Nevada Test Site Field Trip Guidebook. We have a booklet on mines and geological deposits. There is a topographical map in the back of that.

The best place to find the name of the location is to use the topographical map inside that report.

There's also a geological map. That map has been in part on a different scale-- you saw it with Dave. We'll have a copy of that.

In addition, we have some photos that were shown today.

We also have lower altitude booklet, which gives you a feel for where you'll be as your driving along looking at the place.

Do you have any questions?

DR. ISAACS: I did notice that the bus leaves at 6 and gets back after 8. Other than lunch there's no food for the group.

Is it advisable for people to take some snacks with them?

DR. BLANCHARD: Well, we're providing lunch. The lunch is--there's a lot to eat in that lunch. You'll never be able to eat it all at lunch but there is a possibility to eat at the Steak House over at Mercury and for those who would like to eat before going back, we can work out some arrangement.

I'm not sure how many people would want to eat.

DR. WILLIAMS: Do you have any idea where you can get breakfast at 5:30 in the morning?

DR. GERTZ: In this town, any place.

DR. BLANCHARD: Most of the casinos serve breakfast all night.

I may have missed it, the hand-outs are on this table outside the door. There's four things out there.

DR. GERTZ: We have finally produced enough copies for the people who didn't get the presentations this morning.

DR. BLANCHARD: Thank you very much for your patience. We appreciate it very much. See you in the morning.

(Whereupon, at 5:45 o'clock p.m, the presentation concluded.)