NUCLEAR WASTE TECHNICAL REVIEW BOARD

MEETING, VOLUME I

HELD ON JUNE 26, 1989

AT 8:00 A.M.

AT THE ST. TROPEZ, MONTE CARLO ROOM

LAS VEGAS, NEVADA

Reported by: Patti Fernandez C.S.R. No. 129

APPEARANCES:

BOARD MEMBERS

CHAIRMAN	DON DEERE
EXECUTIVE DIRECTOR	WILLIAM COONS

DR. CLARENCE ALLEN
DR. JOHN CANTLON
DR. MELVIN CARTER
DR. DONALD LANGMUIR
DR. WARNER NORTH
DR. DENNIS PRICE
DR. ELLIS VERINK
DR. ROY WILLIAMS
DR. EDWARD CORDING
DR. RUSSELL MC FARLAND
DR. WILLIAM BARNARD
DR. PAT DOMENICO
MR. ROBERT LOUX
DR. ALFORD

SPEAKERS

MR. ROBERT LOUX
MR. CARL JOHNSON

SPEAKERS

MR. CARL JOHNSON
MR. MIKE ELLIS
MR. RICHARD SCHWEICKERT
MR. JOHN BELL
MR. MARTIN MIFFLIN
MR. JOHN FORDHAM
MR. SCOTT TYLER
MS. LINDA LEHMAN
MR. MAURICE MORGENSTEIN
MR. DONALD SHETTEL
MR. EUGENE SMITH
MR. LAWRENCE LARSON

CHAIRMAN DEERE:

Good Morning, my name is Don Deere and I am Chairman of the Nuclear Waste Technical Review Board. On behalf of the Board members, I want to thank you for coming to the second full meeting of the Board.

The first meeting of the Board was held in March of 1989. We have an

ambitious agenda for this 3-day meeting which I will outline shortly, but I want to take this opportunity for those of you not familiar with the NWTRB to provide some background information.

The Nuclear Waste Technical Review Board was created by the U. S. Congress as an independent establishment within the executive branch of the U. S. Government on December 22, 1987 in the Nuclear Waste Policy Amendments Act of 1987.

Our charge is to evaluate the scientific and technical validity of the U. S. Department of Energy's site characterization work at the Yucca Mountain Site in Nevada and activities related to packaging or transportation of high-level radioactive waste or spent nuclear fuel.

We are to conduct our evaluation of such activities since the enactment of the Nuclear Waste Policy Amendments Act of 1987 and report our findings, conclusions and recommendations to the U.S. Congress and the Secretary of the Department of Energy not less than two times a year.

The NWTRB is comprised of 11-members, 8 of whom have been appointed by the President Reagan to date.

The term of appointment for the initial 11-members will range from two to four years. I am honored to have been selected by the President to serve as Chairman. I would like to take this opportunity to introduce the other Board members, in alphabetical order.

Dr. Clarence R. Allen, Professor of Geology and Geophysics, Seismological Laboratory, California Institute of Technology.

Dr. John E. Cantlon, Vice President for Research and Graduate Studies and Dean of the Graduate School at Michigan State University.

Dr. Melvin W. Carter, Professor Emeritus, Georgia Institute of Technology

and an International Radiation Protection Consultant.

Dr. Donald Langmuir, Professor of Geochemistry at the Colorado School of Mines.

Dr. D. Warner North, Principal, Decision Focus, Inc., Los Altos, California; Consulting Professor, Stanford University, Palo Alto, California and Associate Director, Stanford Center for Risk Assessment.

Dr. Dennis L. Price, Professor of Industrial Engineering and Operations Research and Director, Safety Projects Office, Virginia Polytechnic Institute and State University, Blacksburg, Virginia.

Dr. Ellis D. Verink, Distinguished Service Professor of Metallurgy and former Chairman, Materials Science and Engineering Department, University of Florida, Gainesville, Florida.

The day to day activities of the NWTRB will be managed by our Executive Director, Mr. William Coons.

Mr. Coons is a retired faculty member and former Assistant Chairman, Civil Engineering Department at the University of Florida in Gainesville. He is also a retired Captain, U.S. Navy. In that capacity, he was associated with the POLARIS/POSEIDON submarine program.

At the first full meeting of the Board in March, 1989, we established five panels to help us organize our evaluation. The panels are:

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- - Containers and Transportation
- - Risk and Performance Analysis
- - Structural Geology and Geoengineering
- - Hydrogeology and Geochemistry
- - Environment and Public Health

Members of the Board are assigned to panels according to their expertise. For those interested, a list of the current membership of each panel is available on the information table.

The panels have just begun meeting in different locations around the country. If you are interested in receiving notice of their meetings, please sign in on the registration sheet on the information table. We will be sure to send you a notice of all upcoming meetings.

To assist the Board in its scientific and technical evaluation work, we have asked the following consultants and technical staff for their assistance.

They will also accompany us on our field trip to Yucca Mountain.

Risk and Performance Panel

Dr. William Barnard, Office of Technology Assessment, U.S. Congress.

Structural Geology and Geoengineering Panel

Dr. Edward Cording Professor of Civil Engineering, University of Illinois.

Mr. Russell McFarland, Civil Engineering Consultant, specializing in systems engineering, systems analysis, construction of underground facilities, and transportation, Washington, D.C. Mr. McFarland will also be assisting the Containers and Transportational Panel.

Hydrogeology and Geochemistry Panel

Dr. Pat Domenico, Professor, Department of Geology, Texas A&M University.

Dr. Roy Williams, Professor of Hydrogeology and Director, Waste Management Studies. Department of Geology and Geological Engineering, College of Mines and Earth Resources, University of Idaho.

Today, we will be briefed by the State of Nevada. Tomorrow, we will be briefed by the U.S. Department of Energy concerning scientific and technical issues pertaining to the viability of locating the nation's permanent high-level radioactive waste repository at the Yucca Mountain Site in Nevada.

On Wednesday, June 28th, we will tour the Yucca Mountain Site.

Before beginning today's presentations, I want to thank members of the audience for attending our briefing session. We ask that members of the audience participate as observers only during our briefing sessions as we are in the information gathering stage of our existence.

At a later date, we intend to provide opportunity for comment on our activities from any interested person or organization.

We also intend to hold a press conference this Thursday, June 29th, here at the Conference Center in the Monte Carlo Room, to make our activities and purpose more familiar to the press.

For the next three days, however, we stipulate that only Board members and our Board consultants ask questions of the presenters during the course of the briefing.

I also want to thank Mr. Robert Loux, Executive Director of Nevada's Agency for Nuclear Projects, Nuclear Waste Project Office and his staff for preparing what appears to be a very comprehensive presentation of topics of concern to the State of Nevada.

To Mr. Carl Gertz of the Department of Energy, we appreciate your staff's

effort in putting together the DOE's overview of the Yucca Mountain Site and in arranging the logistical support for the field trip to the site on Wednesday.

With these comments, I will now turn the meeting over to Mr. Robert Loux.

(Whereupon Mr. Loux takes the presentation podium at 8:45 A.M.)

MR. LOUX:

Thank you, Mr. Chairman.

First of all, on behalf of the State, I would like to welcome the Chairman and the Board members and consultants to Las Vegas and in the State. For all of the rest of you, who are from out of town, welcome to Nevada. It's our pleasure to be able to make our presentation today. We certainly appreciate the opportunity.

I am Robert Loux, Director of the States Nuclear Waste Office and I will be talking mainly today a little bit about the introductory aspects of our office of what we are up to and how we are organized and some of those sorts of things.

One of the things that I want to cover also, is a little bit of the history of the State's effort in the program to date and then talk a little bit to some of the organizational issues associated with many of the technical issues that you're going to hear today and in further detail from our, some of our consultants.

I note Mr. Chairman, with interest, the description of your Board and activities. The State as well, as you know, under the Nuclear Waste Policy Act as well as the Amendments Act is empowered to conduct independent off-site as well as the department's program and as you may be aware, we have been engaged in their activity for some time.

We look forward to continuing the interaction with the Board and with the individual panels as they have meetings and other activities, down the road and would like

to extend an offer in the State and my office staff, if they can be of any assistance to you while you're staying in Las Vegas and in this area, please feel free to call on us or at any other time as a matter of fact.

CHAIRMAN DEERE:

Thank you.

MR. LOUX:

What I'd like to do first of all is; show you a little bit about how we are organized and talk a little bit about the history of the organization and some of the other things that we are associated with.

The office was created initially in 1983 as a result of the Nuclear Waste Policy Act as is considered or as a response to that on the State's behalf and indeed was put together by the Executive Policy in 1983 and in late 1983, we formally became a small office within the office of the Governor, Governor Bryan at that point and time and received our first grant money from the Department of Energy.

We became a formalized independent State agency in 1985, including not only our organization, but an advisory commission on Nuclear Waste or Projects, which is currently chaired by former Governor Grant Sawyer.

As you can see, we are supported by the Attorney General's Office as well as have an on-going high-level waste study committee or in association with the State Legislature. We fund all of our activities as well.

We generally are organized into two divisions; a planning division which is more associated with the long term socioeconomic and transportation issues and we have a technical division, which we'll hear a great deal more about

today and which is concerned about the site suitable issues associated with Yucca Mountain and we currently have 19-FTE, including clerical staff and full time employees in our office, but we do the balance and majority of our work through contracts and

consultants and probably have in the neighborhood of 150 to 180 individual scientists under contract to the office including both divisions; socioeconomic and the technical issues.

We are charged under State law to perform all of the studies assigned to the State of Nevada under the Nuclear Waste Policy Act and including, we are responsible as I mentioned, for conducting the off-site of DOE's program and again, nearly all of our funds, in fact, all of funding for this program is provided by the Nuclear Waste Fund through grants negotiated with the Department of Energy and also obviously with Congressional Representatives.

In general, we have got a series of goals as you can see and these are somewhat general goals associated with insuring public health and safety in Nevada as well as the environment is protected. (Referring to overhead projector)

We are engaged in complete and full assessment of all socioeconomic and application issues that may result in the projects going forward in the State and of course, we also provide a policy guidance to the Governor and the rest of the elected officials in the State.

Lastly, I want to show with you, at least some of the level of activities that our office is involved with. We went through a lengthy process and I'll describe that in a little more detail in a moment of designing some of the technical issues we think are critical, critical issues to understanding suitability of Yucca Mountain and of course, thereby, the health and safety aspects of Nevadan's and the environment and we do that basically through a 3-stage or 3-tierd process.

The first one being, a review of DOE's plans, studies and documents by not only ourselves, but a variety of consultants. We also are engaged in a Field Monitoring, if you would, of DOE's activities and lastly, on issues that the State believes are critical and serve either because they are not being addressed adequately or the methods are in

somewhat of a question and the agency has engaged in a series or will engage in a series of independent studies, verification studies to confirm various aspects of DOE's program.

This list of technical issues and the first bullet was developed early on in the program, in the early 1983 and 1984 time frame, not only by some of our internal staff, but Carl Johnson, who you'll hear from in a moment and from the other consultants as well as local and national experts in the local environment here in Southern Nevada Geological and Hydrological or Hydrologic environment.

We also conducted a thorough review of NRC's Regulations regarding Repository Development as well as the then proposed EPA Standard which I think or guess in part, is still or has still been re-proposed.

In order to arrive at these issues we thought that were critical, we took a look and I think it's important, an important aspect of the history of the program be looked at and look at the issues identified by the National Academy of Sciences in 1979.

When the Department of Energy originally proposed a depository in the unsaturated zone in the southern basin and the volcanic tuft and also took a look at the only independent review of the Department's program conducted in 1981, the issues that you're going to hear today, are of critical importance, not only from the aspect of regulatory environment, but also these issues have long been identified as far back as 1979, the issues that need to be thoroughly understood and in some cases, at least the NAS recommended understood prior to these commitments of large amounts of resources at the site in that any one of these issues could be terminal for the program at Yucca Mountain.

We find, as you'll hear today, in some of our presentations, that the treatment of these issues is not progressed terribly since 1979 by the department and has remained for the most part, critical issues, at least the State's perspective relative to how

the site may or may not perform all the time.

With that, I'd like to call a halt to the introduction and let you get on essentially with the meat of the program.

With that, I'll go ahead and introduce Carl Johnson. First, let me see if there's any questions from the Board or any of the - -

DR. CARTER:

I have one question.

I wonder if you or perhaps Carl, could give us some idea of the scope of activities as far as the monitoring of the DOE Field and Lab activities in the last bullet, the scope of the independent studies and this is just for the flavor of what source of things - -

MR. LOUX:

I'd be happy to do that.

I think Carl is prepared to talk about those activities a little bit, but I know in general monitoring activities are associated with generally the field activities at the Yucca Mountain site itself.

Not a heck of a lot has been done relative to monitoring laboratory work and that sort of thing, but I think Carl can elaborate on that.

Any others? (No response)

Thank you very much. Again, I wish you a pleasant stay here in Southern Nevada and again, offer our assistance if we can be of any help, please call on us and with that, I'll introduce Carl Johnson, who is the Chief of our Technical Division, head of the Technical Program.

(Whereupon Carl Johnson takes the presentation podium at 8:55 A.M.)

* * *

CARL JOHNSON:

As Bob mentioned, my name is Carl Johnson and I'm the Administrator of the Technical Programs within the Nevada Agency for Nuclear Projects.

This morning, I want to give you an overview of our technical concerns and kind of set the stage for the individual technical presentations that you're going to hear throughout most of the day.

The purpose of today's presentation will be to discuss Nevada's technical suitability concerns with the proposed Yucca Mountain Repository Site.

Basically, the agenda for my presentation, will cover two main topics;

1. Our general site suitability concerns and, kind of provide and overview of our specific site suitability technical issues, which you will hear more and more about from the presentations throughout the day.

As Bob mentioned, our identification and review on the technical concerns with Yucca Mountain dates back to when the agency was first established, back in 1983 and we looked at the activities that went on in the past and the data base that was available at the time and basically identified a number of technical issues which I will talk about a little bit more, but I think I want to set the stage first by making a few remarks and the important one, that everybody has to realize is, is that the 1987 Nuclear Waste Policy Amendment Act, which identified the location as Yucca Mountain as the only site that would be characterized for the Nation's first Repository, did not assure that that was a suitable site for the disposal of high-level waste.

It only stated that that was the only site that was going to be characterized and that's an important point because it gets back to one of the remarks that Bob Loux made in his opening statements and that is, that there needs to be early resolution as to whether the site is in fact a suitable one or not.

And certainly that needs to be done, we think, before we expend vast sums of money out there, 3 and 4 billion dollars.

Next, there's a series of what we have called Regulatory Policy Issues that certainly need to be addressed and resolved before this project reaches the licensing stage.

One of the important ones that we have identified is the applicability of 10 CFR Part 100 Appendix A and for those people not totally familiar with that, NRC Regulations that deal with seismic design of nuclear facilities.

We think there's applicability of that particular regulation to the High-Level Waste Repository Program and we think that certainly needs to be resolved and resolved early because if in fact Appendix A is applicable, then the Department has to take that into account and they are not only in their planning, but in their investigation because it is fairly prescriptive as to the types of investigations that need to be done.

Secondly, there's certainly the question of data sufficiency and I think the Board has recognized that in some of their questions and comments in previous meetings, when is enough data enough data to answer the question and whether there will be in some particular issues, whether there will be sufficient data available to resolve the issues.

Thirdly, there's the long standing question of deterministic versus probabilistic approaches to interpreting the information and resolving issues.

Next, there's a question of concern that we have had and that deals with the question of system licensing.

We believe and we have talked at some length with the NRC Commission about this, that we think that a licensing of a Repository does not just include licensing of the Repository itself, but also includes licensing of the total Repository System that would include the transportation aspects of it and the handling of it at the Reactors and that sort of thing.

Next, we have concern about what is called, "Phased Licensing," and I think we have heard a little bit about this from the Department at previous Board meetings as to the concern over licensing the total Repository or licensing small aspects of the Repository and then modify the licenses as more and more information and more and more area of the Repository is known.

And lastly, which is the issue of land ownership and control which is particular concern to the State of Nevada. As you are aware, we have 3-parcels of land that make up Yucca Mountain that are owned by three different or managed by three different Federal Agencies and there's certainly a question as to whether the Department can ultimately get total and permanent control and ownership of this land, especially or at least in our view, when there's a provision within the U.S. Constitution that in order to or for the Federal Government to obtain permanent ownership of land within the boundaries of a State, it requires the State's concurrence in that.

Next, there's the question of site disturbance issues as to whether sufficient data can be developed for this particular site to present an adequate and acceptable license application without sacrificing the integrity of the site.

In order to do that, there's been some questions that have been raised in the past about the sufficiency of using high resolution geophysics at the site.

If it can't be done, maybe additional borings or trenches or whatever will be required.

There's also questions about penetration of the Calico Hills Tuff Unit, which is the major primary natural barrier that the Department is going to rely on to meet the performance requirements.

Whether in characterizing that particular unit, you have essentially destroyed the waste and isolation capability of the Repository site and lastly, there's the question of the Refracture Systems and whether one can reasonably and adequately

characterize exit with just a site with a multiple of fractures.

Lastly, there's the long-term possible closure issues. This particular project, a High-Level Waste Repository Project is not a short term project in any stretch of the imagination.

We, I think correctly characterize this as a 10,000 year project.

There's certainly some questions then, if it is a 10,000 year project, like the regulations have characterized it, as to whether we have the ability to produce the performance of that repository over the 10,000 year period.

Certainly, some questions about what are the long term risks involved in that and there's questions about whether the engineer barriers will be able to perform over the 10,000 year period and then there's some questions as to or we'll hear about them in some of the presentations which is whether the technology to obtain the information which will allow us to make predictions, is even available presently.

I think, in reviewing the regulations, that the basis of our technical concerns are embodied in this particular provision of 10 CFR, Part 60, Section 31A provides that the Commission will authorize construction, if it determines that there's reasonable assurance that the types and amounts of aid active materials described in the application can be received, processed and disposed of in a geologic repository operations area of the design proposed at the designated site without undue risk to health and safety of the public.

And the reason is, "The reason I think this embodies the essence of our technical concerns lie in the reasonable assurance," and I think you're going to hear that over and over and over again today and that is a major concern as to whether we will ever have reasonable assurance that this particular site will not pose unreasonable risks to the public health and safety.

With that as a background, what I'd like to do is; briefly run through the

technical site suitability issues.

I don't want to spend a lot of time because I think you're going to hear a whole lot more from the individual speakers on the various topics, but I wanted to give you a little bit of background as to the types of subjects you're going to be hearing about in the presentations today.

The first one will be on "Understanding the Tectonic Settings and Its Implications to Site Suitability."

There will be discussions about the geologic processes or concerns with the need to understand the deep geologic structure in order to understand the tectonics processes, earthquake and fault relationships and also the effect of nuclear testing.

This particular site presents a unique aspect there that consider the continued nuclear testing may have an effect long term and possibly short term effect on the waste and isolation capabilities of the site itself.

Certainly, it may have an effect on the stress regime.

Then, a little bit about what are the tectonic affects or what they might be on the hydrologic system.

Secondly, we'll talk a little bit about activity or active faulting. The literature is already identified that there are active faults in and around the Yucca Mountain area.

It's going to be important to understand what the styles of faulting are and what the occurrence rates are and certainly to understand the relationships of these faults to the earthquakes that have been monitored and then try and of course, understand the relationship of this faulting to the current hydrologic regime.

Then, we want to talk a little bit about the unsaturated zone of the Vadose Zone as we have called it, which is, the more I think or I think the more correct term and we want to talk about the relationship between matrix flow and fracture.

We believe that fracture flow predominates at the site or certainly is a major component at the site and we'll talk about what some of our evidence is there.

Then, we'll talk a little bit about our concerns with the gaseous phase movement, which has been identified recently also as occurring at Yucca Mountain and what does that have relative to Vadose concerns and what that has relative to the understanding of the isolation capabilities and transport of regular nucleods.

Next, we want to talk a little bit about the regional flow system. We need to understand the relationship of Yucca Mountain to the regional water flow system.

We know that the regional water flow system has or is a rapid flow time based on studies elsewhere. It also appears that the Yucca Mountain or the major concern is not only ourselves in the State, but also the local governments and Southern Nevada and that is, the implications for future water supplies.

As you may realize in the desert areas of the Southwest, continued future growth within those areas is an aquifer totally hinged on obtaining adequate water supplies in the future.

Certainly, one of the areas being looked at currently for future water supplies is the Regional Flow System and so it's very important that we understand the relationship to this Regional Flow System certainly before this Repository Program is licensed and construction begins.

Next, we want to talk a little bit about uncertainties and modeling and performance assessment. We think there appears to be a lack of currently widely accepted models for modeling the hydrologic system and also for performance assessment. Certainly there's lack of experience in modeling performing for 10,000 years.

Then, there's the question of just the representiveness of the data that's going to have to be used to model these, the site and the performance aspects of it.

Then, the questions of the complexity of the natural system itself and I think

you're going to hear more about that through the course of the day.

We are dealing with the dynamic natural system here of the Great Basin active area geologically and hydrologically.

Next, I think certainly is the question of coupled processes, the relationship of the geologic environment to the hydrologic environment to the thermal environment and the geochemistry area.

We are going to concentrate today on two areas.

1. Retardation and that's being certainly considered by the Departments as a major aspect of calculations of the site and that is the ability of minerals to absorb radio-nucleods if they are released from the Repository itself.

We certainly have some questions relative to that and some major concerns.

Secondly, there's the question of defining and evaluating the disturb zone and that will be the area that will be essentially altered by the radio-nucleods materials and the radioactivities once these materials are placed within the Repository and how large is this area, what types of alterations and modifications will take place and how does that then impact on to waste isolation and performance calculation.

Next, we are going to talk a little bit about volcanicism.

As you are aware and you certainly will see on the field trip on Wednesday, that Yucca Mountain is very near a basaltic volcanic field and it's within the Southwest or Western Nevada volcanic field area.

So, there is the possibility and certainly there has been the work to indicate or has suggested that we have the - - we have had volcanic events within the last 6 to 20,000 years ago and we need to know about being able to predict whether, within the next

10,000 years, we are going to have another volcanic event.

Certainly, we would need to know then about recurrence rates in that regard. We need also to know about the relationship between volcanic activities and the hydrologic regime and lastly, we need to certainly understand the structural control on these volcanic centers, so that we can understand the mechanism that will or could produce future volcanic activities.

Then, we need to - - we are going to talk a little bit about climate change, particularly the effect on the hydrologic system.

We have got, certainly have got some questions about being able to predict changes in the climate over the next 10,000 years and I have put up the quote here, (Referring to overhead projector) that I think are applicable to climate change and that is that,

"The past may not be the key to the future."

In other words, what we have observed in the way of climate change in the past, may not be a key to trying to predict the future of climate change because certainly the greenhouse effect is the one thing that enters into this, which appears to be a man-made effect of recent times and how that gets imposed upon climate change predictions which is something that certainly needs to be considered and evaluated very seriously and thoroughly.

Lastly then, we are going to talk about natural resource potential. We are going to concentrate our remarks on mineral resources.

As you're aware, Nevada is very key to the mineral resources of the United States and we produce most of the gold and precious metals that are produced in the United States right now and we'll hear a lot more about that, but also, which is something that is not well known and that is, that Nevada is also an oil and gas producer.

And the evidence to date, suggests that the same geologic formations that

produce oil and gas elsewhere in the State also occur beneath Yucca Mountain, beneath the volcanic tuff pile.

So, there needs to be certainly some resolution as to whether there is oil and gas potential beneath Yucca Mountain and also there's the geothermal resource consideration since right now, Nevada is second in the nation in the use of geothermal energy for electrical energy and also for other uses of geothermal resources and we do have evidence of elevated water conditions, which could suggest that there may be some potential there.

The or lastly of course, I come back to the subject of water resources and the future water supply considerations.

Lastly here, is that this is a list of the technical presentations that you will hear from throughout the course of today and the order in which you're going to hear about those and we have provided that to the Board, the handouts from each one of the presentations and attached to the back of those hand-outs, is a Resume of the individuals who is making the presentation, so that you will get a little bit more familiar with the expertise and the experience of the individual making the presentation.

With that, I will conclude my remarks and entertain any questions before I have Dr. Ellis come up here and begin the discussion of Tectonics.

DR. CARTER:

Carl, can I repeat the question that I asked Bob Loux and namely, I wondered if you had or if you would take a few minutes to sort of characterize what you do in terms of monitoring the DOE Program and the conducting of independent studies and I'm particularly interested in whether you're reviewing their plan, their design and this sort of thing so or to see that they are adequate or whether you would have a way of an independent program, if you considered that they weren't doing it satisfactorily and whether you'd conduct your own say ground water flow studies, for example?

I wonder if you'd give us some feel for that?

MR. JOHNSON:

I'll be glad to. I'm sorry that it skipped my mind to respond to your question as I was going to do through my discussion, but let me go through that.

As Bob mentioned, we have really 3-aspects to our program and one is a review of the DOE's documents, the literature and we do not limit ourselves to a review of the literature, which they reference, but we also review the rest of the literature base which might be applicable to that subject, so that we can have certainly a more well-rounded knowledge base of whatever the particular subject or issue is.

We provide comments on some of those documents such as the DOE Site Characterization Plan and that sort of thing, which I think some of that, which we have published to date, the Board has been made available or it has been made available to the Board.

Secondly, we have had an ongoing program since 1983 of monitoring the Department's field activities, that is, going to the field periodically and generally it turns out that it can be as much as a couple times a week and just observing the field activities the Department has to dry and get a handle on what things they are doing in the field and what types of techniques of methodologies that they are using and just to get a flavor of the types of information that they are developing as a result of that.

Thirdly, as a result of our reviews of the literature, DOE's plans and this sort of thing and our own knowledge and experience of the physical environment, we have a series of independent studies that we either have on-going
or have done on-going or proposed to do and some of those studies which we have completed and are already in our list of technical reports, which I think the Board has been provided copies of or we certainly can provide copies of those.

We do have a series of on-going technical studies and we have a number of

studies proposed to do in the future and those particular things really hinge on study areas that we don't think the Department is pursuing and those things that the Department is doing, but we think that there are other methods, superior methods in order to get at the data or get at resolving those issues, so we perform those studies.

DR. CARTER:

This is actually the collection of independent measurements and sample analysis and whatever may be involved?

MR. JOHNSON:

That is correct.

Thirdly, there are some studies that we think are key to the points that we are willing to essentially almost duplicate the Department's studies just because we think it's important enough that we, at least in our own minds, verify the work that the Departments do and they cover pretty much the whole range of things here.

Most of our field or a lot of our field work is in tectonics and act of faulting and I think what you will hear today and what you will see is these individuals that are listed here and, also the principle investigators in that independent research that's going on.

DR. CARTER:

Let me ask you a couple of related questions.

One, you mentioned the system approach and the licensing and so forth and I realize that you are basically looking at the DOE Program, but well, there's several other pieces to the total system and I wonder if you'd have any comments about your view, at least, from a technical standpoint of the EPA Standard, if it will apply to the Repository and also the NRC Regulatory Department.

That's not the subject of today's meeting, but I wondered if you could make a comment?

MR. JOHNSON:

I'd be glad to, I think, make some remarks.

I think the EPA Standard is certainly a question of concern to ourselves. There's some question right now that because the EPA Standard itself is that the agency the repulmergation as to how site characterization can go forward without having a standard in place by which one, the or can target a particular program.

As of last Thursday or Friday, a new draft of the EPA Regulations were issued and of course, we are going to be reviewing that and making comment on it just like you have made comment on the previous drafts of the Standard.

We certainly have some questions about some of the release limits and that sort of thing that are proposed within some of those standards.

Now, relative to the NRC Regulations, I think that they certainly are a reasonable standards and regulations and I think there's certainly some questions about the applicability of some of those standards, some of those regulations to an unsaturated zone environment.

I believe when Part 60 was originally promulgated, that the concept of an unsaturated zone Repository was not really fully understood and considered at the time.

And so, there's a need to be then probably some interpretations made as to how those regulations are going to be applicable to an unsaturated zone site.

Another thing or aspect that I talked about earlier and that is, the applicability of some of the nuclear reactor - -

DR. CARTER:

Part 100?

MR. JOHNSON:

Yes.

DR. CARTER:

The other question is; you have had 6 years worth of experience and are

now dealing with the Yucca Mountain Projects Office and the DOE in general regarding the Repository.

What sort of relationship do you have?

Is this a smooth thing? Do you get the information you want or do you have difficulty?

MR. JOHNSON:

I - -

DR. CARTER:

There is no DOE people here.

MR. JOHNSON:

So I can talk candidly, but I think to put it very candidly, it's been a very rocky road with a lot of ups and downs in it.

Data transfer has been one of the main let's say bones of contention for a long, long time.

In some areas it's improving and in other areas it's still a problem.

DR. CARTER:

This has to do with timeliness as far as you're concerned of getting information, technical information; is that what you're saying?

MR. JOHNSON:

Timeliness and in some cases even obtaining the information period. Another question that's been certainly a rocky road, has been the State's ability to get to the site to do the technical studies that it wants to do.

I think those are the kinds of main bones of contention, although, another aspect now that I think of it has just been getting the necessary funding from the Department of Energy to do those independent studies that we think needs to be done.

DR. CARTER:

What about the representatives that you have for observation and monitoring on the site? I presume there's no problem with that sort of access?

MR. JOHNSON:

No, that has not really been a problem, access to the site for the purposes of monitoring has not been the problem.

Access to the site to do independent studies has been where the problem has been.

Any other questions? (No response)

With that, I'd like to turn it over to Mike Ellis, who will kind of give a background on tectonics on the Great Basin to set the stage for a lot of presentations today.

(Whereupon Mike Ellis takes the presentation podium at 9:35 A.M.)

MR. ELLIS:

My name is Mike Ellis and the Tectonics presentations during the next half hour, have been split up into two, 15-minute segments and my charge for the first 15-minutes is to talk about the active Tectonics or the modern deformation of Yucca Mountain region.

The main points that I wish to make and first of all, I'll go through the geological context of Yucca Mountain and preview some sort of context.

My point behind doing this is; first, to emphasize the fact that Yucca Mountain is part of a larger system in that it's first emphasis in the Yucca Mountain is part of a larger system and in order to understand Yucca Mountain, at least anticipate the process that may occur during that 10,000 years, we have to understand the region as well.

I also am going to go through this first aspect to set the scene for subsequent presentations and also will go through this first aspect to emphasize the fact that it's not a normal engineering problem inasmuch as we do have to anticipate the next 10,000 years of our geological processes.

The next point I'll make; I'll touch upon the Regional Seismicity and Potential for Temporal and Spatial Clusters and lastly, I'm going into seismic modern deformation of the Southern Great Basin.

In other words, I'll talk about the types of structures and the doubts that we have about those structures that sustain that seismicity.

If I don't get to them in a timely fashion, my conclusions are simply going to be again; Yucca Mountain is part of a complex geological system and in order to understand it and anticipate or predict processes that go on there, we need to have a good handle on the region in which it is.

It's a single component and clearly any interpretation of Yucca Mountain must be consistent with that of the region.

We must also be certain that publistic analysis, there is a typographical error or spelling mistake there, analysis are provided a thorough data base if they are going to make any sense at all.

Let's move first of all to the big picture and as you're well aware, Yucca Mountain lies within the basin range and in particular lies within the Southern Great Basin. It's not marked here and I'm afraid this diagram did not copy very well.

Yucca Mountain is about there. (Indicating on overheat projector)

On the map, the green is the Basin Range and I put this into a context of Tectonics setting. There is some pertinence to this because Yucca Mountain is part of that system.

If we can understand something about the Tectonic setting, we'd have the first step towards understanding the anticipated deformation at Yucca Mountain.

We know from various satellite base studies and very long base line studies that the western margin of the U.S. is dominated by the relative motion of the Pacific plate to the North American Plate.

The boundaries between these two plates is the San Andreas Fault, but the entire region throughout this here and somewhere off shore away from the off short deformation there.

Now, it's true that the San Andreas Fault does accommodate most of that displacement or relatively, but not all of it.

Here are some of the other - - here are the strike slip factors that correspond to the relative motion and you can see that this large specter here corresponds to the total relative motion between the Pacific and North American Plates and that's made up in the way that it's portrayed here, at least made up of the San Andreas slip, which is the longer vector and two shorter ones and the basin and range extensions at the top of the coastal California deformation.

We have quite a lot of good information about the San Andreas, but not very much about the Basin Range and not very much for the basin and the range to a large extent from geological evidence and its constraints are really very important.

As an example, some recent work that has only come out in the past few years, perhaps from Northwestern University is showing that modern deformation of the basin and range is not in this, but it's like in the Northwest of it, like that, (indicating) and the implication behind that is simply that the basin and range is not extending in a simple pear-shape fashion, but has no or some rotational value.

What that boils down to is the deformation is a lot more complex in the basin and range than perhaps we have been thinking, the basin and range extension.

This is already well known by geologists and in part, why they, the geologists didn't discover tectonics and this shows a whole style of or one way of looking at the structure of Nevada and the sort of nasty pink color here are ranges and the white are basins in between virtually every range and that is the boundary between the range and the basin which is marked by an active or recently active fault and you can see some of these

dark lines running adjacent to these ranges.

The topography is produced directly by this deformation and you can see in the central part of Nevada that it's fairly regular.

You have a series of north and south trending ranges and basins that reflect extension and in a very, very crude fashion, when you think of these as stretch marks.

There's also some geological maps and satellite photographs at the back of the room that you might want to peruse during the break later, but in the southwest or western part of Nevada here, as we are coming through the southern Great Basin, the topography is a lot more complicated and generally a compass which reflects simply an anonymous and more complicated structure.

This region is known as the Walker Lane and the Walker Lane is somewhat of an enigma in that this is demonstrated by one of the workers in the field who recently extended the Walker Lane belt to include this triangular region in California which includes some of the major active faults.

Here's Yucca Mountain and as you can see and I have marked in these major faults, Death Valley, Owens Valley and you know quite well from driving down 95 from Reno to Los Angeles or something like that.

Don't take from this diagram that there are no major active faults around Yucca Mountain. There's a large region here which is completely inaccessible, far less than Tibet for example, where there is some major faults, but it is difficult to see what's going on.

I don't mean the Test Site - - I don't mean the Test Site, but also mean the Bombing Range and just to relate this back to the last few diagrams and the point that I'm making about the regional setting of the modern deformation activity, right now, in the basin range which is a lot more complicated than a simple extension of region.

There is very complex structures, not only within Walker Lane from this

region here, but also within the rest of Nevada and some of our own work is shown that.

For example, the strict slip deformation is a lot more common than people have anticipated.

DR. CARTER:

I wondered if you'd refresh our memory; what is an active fault?

MR. ELLIS:

One that is sustaining seismicity now or starting to extend or shorten a particular region, that is one example.

DR. WILLIAMS:

What do you mean by "now?"

MR. ELLIS:

Active faults, one is active say over the last 10,000 years and there are other criteria too. If that fault has sustained seismicity in one or two times in a 500,000 year period are considered to be active.

MR. JOHNSON:

The NRC Regulation identifies an active fault or a fault that needs to be of concern relative to a Repository Project is a fault moved within the pattern ternary time period.

DR. ALLEN:

Are you using the NRC criteria? Of course, they talk about the capable faults, but what does the State of Nevada usually carry?

MR. ELLIS:

I'm using the active fault in the sense that it's a fault that has been active and definitely in the or most likely in the or is typical of sustaining an earthquake in the next 10,000 years and probably I'm not using it in the strict sense of somebody who works in seismic topography.

DR. DOMENICO:

I'm familiar with the Walker Lane Fault in the Reno area. Has it always been thought to extend down into Las Vegas or is it a new finding?

MR. ELLIS:

That's a point of concern and certainly in terms of structures.

It tends to end in a strict sense at Tonopah, which is about here (indicating), but there are structures such as the Las Vegas Shear Zone, which come North of Las Vegas and ends at Lake Mead basically that are considered to be part of that Walker Lane Belt.

DR. DOMENICO:

That's a recent interpretation?

MR. ELLIS:

No, that's fairly - -

DR. DOMENICO:

An old? Because I assumed that it ended at Tonopah.

DR. CARTER:

Tonopah is roughly 100 miles north from the Test Site?

MR. ELLIS:

Right. I'm going to touch on the regional seismicity and the potential of spatial and temporal clustering.

I don't think it needs to be said why seismicity is important to the various licensing issues here, although, this list serves to remind us that seismicity does have an effect on ground water flow, mineral resource potential and strong ground motions during seismic events and ground deformation due to events that are blind or buried faults.

The point that I'm talking about is a potential for spatial and temporal clusters. This makes a production of a system hazard far more difficult than it might be otherwise.

This map shows the seismicity and part of the Great Basin from 1852 to 1988 and does not include various seismic events which have been picked up by the University of Utah Network, so this area here is a blank for reasons of data omission, but it basically includes just about everything else.

This cluster of seismicity is as a result from the weapons testing and what you can see here is in this time period a specific time zone or seismicity.

It's concentrated in this central Nevada belt, yet on approximation, the Great Basin is relatively homogeneously extended and extending.

So, we have here a case, at least for maybe some temporal clustering and spatial clustering also.

DR. BARNARD:

Where is Yucca Mountain?

MR. ELLIS:

It would be about there (indicating), south of the weapons testing. These diagrams show schematically the effect of temporal clustering and in this diagram which is essentially taken from an article by Bob Wallace.

Bob Wallace is well respected, a well respected seismologist or concerned with paleo seismology or ancient earthquakes in the Great Basin region.

In these types of temporal clusterings, say we have a region that is going through a, given by this line here, overtime, the displacement amounts to this much on the ordinance that that deformation may be made up of clustering of high rates of activity or low rate and high rates and so on, as opposed to a more regular deformation as shown in the lower diagram.

Now, this is particularly pertinent in the summer Great Basin because the style of deformation is distributed defused so that we may expect that seismicity switches on an off and on and migrates from one to the other.

It's being shown relatively as simple faults systems such as segments of the San Andreas Fault.

We can make that picture more complicated by asking or showing that seismicity can be spatially clustered also and this is a diagram which comes from Ambrasyes work to imagine two sub-regions within a region, say within the southern Great Basin, it's possible that one of the sub-regions is deforming in this fashion of high activity, low and high and at the same time, you can imagine that at this time that corresponds to this point here, which is the same as the time here at the same time, adjacent regions may be deforming at a high rate of activity. (Referring to diagram)

You have got high gains, low and high upper gains relatively low rates of activity here. If you add these two together, at the region or as a whole you'd see the deformation as relatively uncial.

Let me point to a quotation from Ambraseys 1989 articles. It's simply not logical to ignore the possibility at all of our observations may be questions as to period of seismic activity of a region. This is a chief region and why statistics are based on support data and alone do not provide reliable system of earthquake hazard.

This is a specific diagram from Ambraseys work which is actually in the border zone in Eastern Turkey, showing this type of schematic diagram can be made into something specific and not some flight of the imagination.

DR. CARTER:

In that area of the world, isn't that one of the more active areas in the entire world as far as seismicity is concerned?

MR. ELLIS:

That's true. I want to say that I'm making a direct analog between this part of the world and this, but I am pointing out that the basin or the Great Basin is also very active and we should expect similar complications.

DR. CARTER:

The two regions are quite different from the seismic standpoint?

MR. ELLIS:

They are quite different in tectonics and in a standpoint as far as you don't really know very much about the seismic or the southern Great Basin area because ancient civilization in that part of the world would know, they know more about the ancient seismology than we have here.

DR. CARTER:

We do have major earthquakes there that are quite devastating in terms of human loss of life and structural damage and we have never had those in this area?

MR. ELLIS:

There have been major earthquakes in the Great Basin about 5 or 6 earthquakes of magnitude, 7 1/2 and that's only in our time or our lifetime and it's entirely possible that there may be major earthquakes, for example, in Death Valley before our time and in fact, that's a certainty.

DR. ALLEN:

Wouldn't you agree that this phenomenon, and I agree with Ambraseys and I work together in that area, but this is all the more reason why the geological studies are important to integrate over a long period of time, earthquakes and - -

MR. ELLIS:

Yes, I completely agree and that's probably the point that I'm trying to make.

We'll move now quickly to Mechanism of Deformation and is somewhat motivated by our ignorance of the basic structure of Yucca Mountain itself. There are a couple of

There are a couple of cross-sections on the top and one is made by the

U.S.G.S. personally and the other is made by us and I'm not going to say which is right, because I don't know which is right, but the point is here; if either of these and actually the westward or the lower one has a better representation of surface data, but nevertheless, it might be this one that is right also and we really don't know yet.

There are very different structures in here and some that are uncommon and there's what is called a detachment and low angle, normal fault and high angle fault, which go down to the base or the seismogenic zone, which is about or between 10 and 15 kilometers in this part of the country. (Referring to map)

DR. BARNARD:

I have got a question there. If you look at the structure on either side of Yucca Mountain on Calico Hills where the mountain appears to be less complex, is that because those structures haven't been put on your diagram or are they in fact less complex structurally?

MR. ELLIS:

Mainly, they have not been put on the diagram. I tried to make somewhat of I tried to make somewhat of a schematic of an example of how much we really don't know about the region and it's true to say that the southern Great Basin is a nurturing ground for some news ideas that are coming out and about how confident the continent extends and here are some models that have been presented.

The top one is the more example of expansion of the basin drain in describing it as a series of coast and high

The lower one is more modeled or a model was developed in the early '80's which consists of low angle structures across which there are large magnitudes of disciplines and these may be limited to the upper crust in part.

The third model is what's called a rolling hinge. You have to imagine here at this point with what's attached to this point, (indicating) and that all of these pieces as

what would now be recognized as ranges have been chopped off of this unit here and transported on this and now are inactive faults.

This attachment here used to be this high angle fault that is shown here and the fourth model shown is a conduit slip fault where there may be associated low angle faults adjacent to some of these strike slip faults.

It's likely that these models are correct to some degrees and at different times during the development of the basin and drainage and we really don't know as to which is appropriate, if any at the southern Great Basin and Yucca Mountain region.

As an example of this strike slip, the basic structure of Yucca Mountain, you can look at one particular aspect.

You saw from the two cross-sections I showed you a few moments ago that our cross-section contains high angled faults and the U.S.G.S. contains low angled normal faults with attachments.

The inferred low angle normal faults come from the fact that what is called the hanging wall rolls towards the fault which is exposed to the surface here and notice that the limit of our direct observation is at the most, 2 kilometers.

This same type of roll over geometry can be established to a plainer fault so there's ambiguity in inferring this structure whether the fault is curved and flattens at some sallow depth or continues to greater seismogenic dense. This is very important.

It's more likely that this fault may be able to sustain a larger earthquake.

So, the conclusion and let me stress again that in order to accurately anticipate the geological processes that Yucca Mountain over the next 10,000 years, we need to understand or begin to understand the geological system which is the proposed Repository site components and this requires regional and seismic studies in that geological research in this research is continually breaking ground.

It represents new concepts and this sense, the various hypotheses imposed

require careful evaluation and yet probabilistic analysis will ultimately yield the engineering perimeters for any Repository design, we must be certain that the data base for those probabilistic analysis are as thorough as possible.

Any questions?

DR. DOMENICO:

Do you have, you show there's some significant difference in your interpretation and DOE's interpretation. I have a question with the spectrum of this Repository and what are the implications of those and what are the changes that may be resolved?

What does that mean?

MR. ELLIS:

The differences in cross-section, one from a seismogenic point of view is; if the fault is active and do extend to a greater depth than provided in the U.S.G.S. cross-section, it may be capable of sustaining a larger earthquake, because they extend down to the region.

DR. DOMENICO:

Does U.S.G.S. claim that they are not active?

MR. ELLIS:

No, they do not claim they are inactive faults, but as you can see from the cross-section, many of the faults curve and sallow at the depths, so that's one aspect and the second is that the basic difference in that structure will definitely affect the position of various aquifers and aquitards clearly.

DR. DOMENICO:

Is this a deterministic problem to work out what is happening down there or will you always have the difference in interpretation?

MR. ELLIS:

As a scientist, you appreciate that it's always impossible to say that I can absolutely be certain which of these is correct. Is it a deterministic problem as far as I'm concerned and it's not uniquely resolvable, but resolvable more than it has been so far.

DR. DOMENICO:

Can I assume this is one of the studies mentioned earlier where the State is taking on its own?

MR. ELLIS:

Yes. I meant to make the point to follow up on Carl Johnson of the things that I have talked about, are things that we are doing and as you know.

DR. CARTER:

Let me ask you something about the DOE program.

I presume from the seismic standpoint, particularly with the advent of the underground tests which goes back 20 plus years, they have instituted a rather elaborate seismic problem, not only locally, but regionally.

Does that - -

MR. ELLIS:

The DOE, U.S.G.S. is in the process of establishing an extensive local seismic program, but from what I can tell, mainly by reading the SEP, the DOE does not appear to appreciate that it's important to look at the regional seismicity or geological evidence or beyond a distance at which an earthquake may directly affect Yucca Mountain.

Perhaps I could or should, maybe it's not sufficient, but I believe to restrict analysis or restrict their analysis to faults which directly affects Yucca Mountain, should an earthquake be sustained on that fault.

It's important to go beyond that first geographical area and in particular to know the seismicity of the region.

DR. CARTER:

I presume in your regional study, the boundaries of this are major faults, is that right? They, to some extent, protect the regional concept, is that essentially how you define seismic region for example, to the west would be a protective barrier from an event that occurs?

MR. ELLIS:

I certainly wouldn't worry about it as far as seismic region is concerned. I would suggest that it's necessary to go and study this entire system here that includes the entire southern Great Basin and doesn't go as far as the San Andreas.

I'm not suggesting that we need to study the San Andreas, heaven forbid, but it's necessary to understand this link system that we are incredibly ignorant about and we know more about Tibet than we know about here.

DR. ALLEN:

You made the statement that most of the mountain ranges in Nevada were bordered by active faults or recent active faults, whatever that means. Then, you define active as - -do you really mean most of the mountain ranges in Nevada are bordered by active faults, is that sort of a new interpretation and I realize some of them are.

MR. ELLIS:

I shouldn't go as far as doing or saying most of them are bordered by active faults, but I would say quantitarian faults.

DR. ALLEN:

I would agree since the word active fault injures the meaning of seismic hazard to the public in particular and I think we have to be very careful how we use this word and the NRC has been very careful in defining capable faults and so I urge us to be careful in how we use these terms because it does involve a percent of seismic risk and indeed I think you'd agree that all degrees of faults of very highly active to non-active.

MR. ELLIS:

We will be talking about the Tectonic frame work.

CHAIRMAN DEERE:

I think we'll take a 15-minute break now. She has to change tapes.

(Whereupon there was a recess taken in the proceedings at 10:10 A.M.)

(Meeting resumes at 10:30 A.M.)

(Whereupon Richard Schweickert takes the presentation podium at 10:30 A.M.)

MR. SCHWEICKERT:

My name is Richard Schweickert and I'm a Professor of Geology from the University of Nevada, Reno, and also the principle investigator for the State of Nevada.

Whereas Michael Ellis earlier discussed the prospects of active tectonics of Yucca Mountain area, my mission this morning and the remaining time that we have allotted to us is to talk about the broader aspects of the somewhat less active tectonic frame work of Yucca Mountain.

So, my general purposes are two-fold.

One is to briefly outline the older tectonic framework and the principle tectonic features that make up the Yucca Mountain region.

I will try to emphasize the importance of some of these features to some of the suitability issues and in addition, my second aspect of my purpose is to clarify the State's concerns about some of the studies that are required for the characteristics and some of the aspects of the feasibility of the site characterizations. I'll give you my conclusions now. Now, we feel that the fault in the Yucca Mountain area are difficult to characterize and will continue to be difficult to characterize in the future for several reasons, two of which are shown in the next two items.

The exposed fault at Yucca Mountain probably are neither pure strickeslip

faults nor pure normal faults.

Secondly, there are several or actually numerous classes of faults at Yucca Mountain that are concealed that is not exposed on the surface and while we know next to nothing about these faults, these may in addition to contribute to the seismic and resource potential of the site because they are concealed or buried.

It means that they are going to be inherently or extremely difficult to characterize.

Finally, the complexity of the sub-surface structure as hinted at in the cross-section that Mike showed you earlier and I'll show you again, may make it impossible to develop unique models of structure or to develop realistic boundary conditions for ground models.

So, we'll start off by looking at the oldest of aspects of geology of the region.

The basin arranged province is outlined in red and along the western edge of it and through the northwestern part if a major bathelet (pho.) belt and where there is construction of Mesozoic age.

The basin bathelet belts are superimposed as much older frame work, which is characterized by the rocks shown in light blue and those are in purple. (Referring to overhead projector/slide)

The area shown in light blue is known as a mylonite and this consists of sediments deposited upon an ancient rifted margin of the North American Continent which range in age from paleo-poric (pho.) to lithoporic (pho.)

They are important because of this high degree of predictability. Number one, it's a westward thickening and tapering edge of sediment and it's very thin along its eastern gauge and it then thickens to 5 kilometers on the western part.

These rocks are also important because they comprise two regional

carbonate aggregate. These two regional aquifers are here so the distribution of these rocks in the subsurface are bound to be an important site suitability issue.

What is the simplicity of the last map is somewhat more detailed representation of units and structural features of the Nevada Test Site region.

That westward tapering prism sediment deposit upon the margin of the Northern America was highly compressed and several mesozoic.

What developed was major regional differential, each of which is shown in a different color.

The area around Las Vegas and areas to the east are relatively undeformed in mesozoic times and piled upon it in successive fashion from the west and there are theories of thrust sheets and the last one shown in red comprising some of the ranges immediately west of Las Vegas.

Piled on top of that is another one in this area here (indicating) and in the Test Site region and there's several different colors yet showing high thrust sheets.

Bear Mountain is shown here (indicating) and you probably can't make it out, but in the first field are the letters YM, designating where Yucca Mountain is.

There's a high degree of predictability to the thrust belt, because each of these thrust sheets contain a characteristic series of stratigraphic units and characterize structure, but there lies a major complication that occurs within the Test Site region and only recently has been appreciated.

Instead of all east virgin or east moving thrust sheets in the Test Site region where is shown this purple band, there's an important area of western virgin thrust faults and west virgin folds.

As shown diagramically, this type of structure undoubtedly extends in the sub-surface beneath the Yucca Mountain area and makes it much more complicated to predict the geometry of tests and other aquifers.

This focuses in a little more closely on the Test Site region and the scales shown here are 40 kilometers and here's the State line and Yucca Mountain is right there. (Indicating)

I call your attention to the units shown in red, which are treasury volcanic and sedimentary rock. These are plastered upon and this older thrust fault or faulted terrain, is made up of some of these units are in blues and the blue in general are "coordinate aquifer units," and the browns are classic aquifers in some of the different mountain ranges.

So, much of this paleosesis and mesozoic geologists concealed by volcanic and sedimentary deposits by the southwest volcanic field. Indeed those are the deposits that seem to be the prime target for the Repository for Yucca Mountain.

Take some of our new work at UNR, which is still unpublished, but now suggests strongly that this pile of volcanic and sedimentary rocks also conceal the older extended terrain and there lies a major episode of extensional normal faulting that predates the development of this volcanic field.

So not only does the volcanic field conceal older thrust faults, but conceals older extension faults as well.

In addition to that, we feel there's growing evidence for the systems of a major strike slip fault, older than the volcanic field and roughly this position that may in fact pass beneath the great flat area.

We'll come back to these briefly towards the end of my presentation.

If we look at the surface structure which can be directly observed in maps, we have somewhat of a different picture.

This map shows mountain ranges in yellow today and also brown. The areas shown in yellow are areas involved in the large amount of late scene seismic extensional and strike slip deformation and the areas in brown are areas that seem to have

escaped very much of the normal faulty and strike slip faulting with the exception of this region, where the Las Vegas Valley Shear Zone passes through one of these zones.

Las Vegas is about here and Yucca Mountain is right where this red dot is. (Referring to slide) What we can see is originally an exposed fault and there are 3 or 4 important types.

The faults that I haven't colored in intend to trend north/south or high angled, faults having modest displacement, at least in the Nevada Test Site region in an area peripheral to the Test Site and there are other types of normal faults shown in green over here.

These are known as low angled normal faults having very large displacement and they are sometimes referred to as detachment faults.

We have reason to suspect that older attachment faults at depth below Yucca Mountain, you can see much of the extensional deformation having been involved in the development of the low angled normal faults.

Perhaps the most obvious structural feature on this map at this scale are the faults shown in red. These are strike slips of various dimensions of types and agents comprising two sets and those that are trending northeast tend to be seismically active and show evidence of left lateral displacement.

Those that are trending northwest are right lateral faults and some of them are seismically active and some of them we know have or we know very little and in particularly these in this region that are trending almost directly for the Yucca Mountain area, we know very little about.

These northwest trending faults are part of this Walker Lane Belt that Mike eluded to earlier and more will be said about today. This map shows the regional development of Walker Lane Belt on the scale of the entire State and there's the State line.

It seems curiously to reflect geographic boundaries as well as geological boundaries, so the most important characteristic of the Walker Lane Belt is the existence of the major right lateral northwest fault.

They do not form a continuous series of faults. It's not a continuing one that passes through the Reno area and Las Vegas, but instead, the belt is highly segmented regions or characterized by northwestern trending with right lateral fault and areas characterized by the northeast trending left lateral fault, such as here and such as here and here.

Very little is understood about the regions or the timing or the development of the fault within this region, however, one thing that can be said is that; fracturally all the faults within the Walker Lane Belt show some components
of normal and some components of strike slip displacement.

Focusing for a minute upon the Yucca Mountain area itself, this is a map produced by the U.S.G.S. of some of the volcanic units

This makes up the Yucca Mountain area and is shown in the, I guess you might say the reddish brown color, which is the most wide spread unit or paint brush tuff and the Repository block is shown by this line. (Indicating)

Some younger ash flow tuffs and the Timber Mountain tuffs are shown in red and some older ones are shown in red and the purple shows some lava flows.

At Yucca Mountain itself, it is thoroughly evident that the exposed surface faults consist presently of north trend steeply dipping faults that have normal displacement at the surface.

There's an unknown component of right lateral displacement bounded to the north. This domain up north trending faults seems to be set of by northwestern trend faults in the Yucca Wash, which are inferred to have right lateral displacements.

They are northwestern trending faults down in this region that have

probably left lateral displacement so there's a fairly complicated faulting at which John Bell, the next presenter will go into this in much more detail.

This is the only or the surface exposed fault and it shows us little or nothing about the deeper varied or blind faults that I have eluded to already.

An important result of studies by the U.S.G.S. involving paleomatrix shows north to south where in Yucca Mountain there has been 35 degrees clockwise rotation during the developments of these faults. The implications of this are as uncertain.

So, back to the cross-section that Mike introduced you to a little while ago. Showing what essentially is two cartoons of structural development of the Yucca Mountain area, I think it's important to point out that this cross-section was derived almost exclusively from studies at Yucca Mountain without much consideration of regional geology beyond the area of Bear Mountain.

The area we feel is more reasonable that it's not an accurate representation, but more of a cartoon which is based upon a consideration of regional geological aspects of the entire southern Nevada area and we feel that there are several different types of fault present here, not simply the exposed fault at the surface as depicted here.

Instead, we feel that there are 4 or 5 classes of faults that must be dealt with in the exposed faults of the surface may well be deeply penetrating faults as portrayed here and in addition to that, members of the U.S.G.S. have proposed that the greater flat terrain area comprise a middle miocene (pho.) caldera bounding fault and probably exists within the subsurface as shown by this enlargement of this area down here.

So, some of the deeper stratigraphic levels of the volcanic sections almost certainly could be expected to have been displaced and these faults would not extend to the surface.

In addition to that, the prevolcanic extensional phase have likely produced low angled detachment.

Faults cannot be proven but strongly I suspect that these are shown beneath the purple units and unfortunately, this part didn't come out very well on your copy, but also shows diagramically aver very simplistic, important areas of mesozoic thrust faults which are cut by all of these cursory faults and once again, the importance of these is, they may control the distribution of aquifers and aquitards and I don't know that any one or any more of those older faults exposed to the surface could be conceivably become activated during the stress regime and could be active now.

It's well known that in seismicity, Yucca Mountain is quite diffuse and not easily assigned to any of the surface faults and for all we know, some of these faults are currently active at low seismic rates.

The final major tectonic feature to point out and this is something that will be addressed much more specifically later on by Gene Smith, but is a belt of particular volcanic rock that runs northwesterly which is referred to as the Pancake Range of the Salt Belt in Death Valley and the Baltic Rock shown in green colors are those that have been indicated as being pre-mesozoic, mostly blyasene (pho.) and they extend from central Nevada on down to the Death Valley region.

Shown in red are the younger basalts and those are preatory in age or suspect praetorian in age.

The major center in the Pancake Range and intricately a northwestern or westerly alignment right through the greater flat along the west side of Yucca Mountain.

This alignment happens to coincide exactly with the position of an inferred pre-fourteen million strike slip fault and we have identified on the basis of our regional studies.

So, let me summarize some of these faults that we think definitely and probably exist in the Yucca Mountain area.

Down here are the exposed faults. These are the only faults that show so far

that have been addressed by the DOE's site characterization plan. These are north trending.

These are north trending steeply dipping faults that indicate the paint brush truff which is 13 1/2 million years old.

They show evidence themselves of a complicated history and show evidence of displacement prior to the eruption of Timber Mountain Tuff somewhere between 13 1/2 and 11 million years ago.

In addition to that, they show moderate normal strike slip displacements sometime during the possible Timber Mountain interval or possibly the last 6 million years.

This is all currently proposed for studies in our reading of the site characterization plan, but we think there are at least 4 other important classes or faults that need to be looked at and the only way to address them is from a very broad regional study of the type that Mike Ellis has already told you about.

We have got in to the mesozonicc thrust faults with their complications and their faults east and the west virgins and they are known to place urbanite aquifers on top of plastic aquitards, so they are important to the entire picture.

This is a new development that we have recently identified although we have been suggesting to the DOE for over a year and a half and these things probably exist, but you need to look for them and this is another new development that nobody suspected before except until you go back to early literature in southern Nevada.

The U.S.G.S. has pointed to the existence of future zones or zone faults and the important thing is; the first 4-categories are all buried and inaccessible from direct surface studies at Yucca Mountain. Possibly some.

Possibly some geophysical studies could identify these, but we find it hard

to believe that geophysical studies would allow any of these to be resolved.

Some thoughts about the potential significance of these older buried faults include several key site suitability issues.

They could be reactivated under different stress regions as I have pointed out and they could be active now at seismic rates and may well have a significant impact on ground water flow pads.

They have an unknown potential for the development of hydrocarbon tracts and/or channel waves for hydrothermal fluids and it's very likely that they could provide conduits for basaltic magna during erupted events.

So, I have got to my conclusion and once again, we think that the fault at Yucca Mountain are going to be very difficult to characterize, largely because the exposed faults that can be seen on map and studied directly are not going to be simple strike slip nor dip slip faults, but instead may have a composite or complex history.

Those are only one of at least 4 or 5 classes of faults, most of which are concealed and all of which may contribute to the seismic resource potential.

If you look at the simplistic cross-section, we drew for illustrative purposes only, it will give you an indication of the complexity of the subsurface structure that may make it possible to develop unique structural or tectonic models for the Yucca Mountain area or to the realistic boundary conditions for ground water models.

I will be happy to take any questions.

DR. ALLEN:

You seem to be saying that the faults are buried haven't broken in millions of years are sufficiently worrisome in terms of the next 10,000 years and that we should consider them seismic or seismogenic, is that what you really mean,

that the fault hasn't broken in millions of years and we have got to worry about that?

MR. SCHWEICKERT:

I think that's an extinct possibility, yes. Recent experience in California for instance, and other parts of the world in compressive tectonic environments have shown convincingly unexposed or buried faults could have large seismogenic potential.

Admittedly, those are virgin tectonic environments unlike the extension environment here, but I think the important point is, not so much as they may be seismogenic, but simply that they are an unknown or has not been coated by any of the known or proposed studies to date.

DR. ALLEN:

Of course, the blind thrust that have broken in California and other places are on active structure and have had many earthquakes that usually reflect and have growing inclines in various features and in saying that that fault hasn't broke for millions of years and are likely to break in the next 10,000, that's a little bit different, it seems to me.

MR. SCHWEICKERT:

Well, faults don't have to break to surface as you're aware to have seismic potential as in the Coalinga Earthquake case and I'm not drawing a complete parallel because I don't think it's any requirement that the faults show up at the surface to have seismic potential, but that's the point I'm trying to make. I addition to that, there's situations far beyond the question of seismicity. They are seriously affecting our ability to characterize the distribution of subsurface aquifers and aquitards.

DR. ALLEN:

And as far as I'm aware, the only large earthquakes that have occurred on faults not exposed to the surface have been in fact on blind thrusts where the deformation still is associated with them can be well recognized in terms of active faults and so forth.

It seems to me just a specter of buried faults breaking anywhere in the

world is not really a legitimate kind of concern.

MR. SCHWEICKERT:

I don't think - - I didn't attempt to raise that aspect, but simply point out that these may have seismic potential.

That's only one aspect of their importance to the site characterization.

DR. DOMENICO:

It seems like you're dealing with an awful lot of geological details here that's not going to be revealed or you say, difficult to characterize. Maybe you mean impossible to characterize?

MR. SCHWEICKERT:

I think sort of a major extensive drilling program potentially would violate the integrity of the Repository and we'll never know in detail all of the geometric aspects of the fault at depth low in the volcanic pile and within the paleo rocks below.

Certainly geotechnics will enable us to imagine certain faults and I suspect interpretation will always remain indiguous.

DR. DOMENICO:

Does it seem reasonable to attack this problem of seismicity from a probable approach or are you - -

MR. SCHWEICKERT:

I would not argue that. I wouldn't want to go as far as to argue that the geological or geologic complexity in the subsurface would rule out that approach, but certain aspects of the deep level geology or the mesozoic thrust faults and the older detachment faults and the older strike slip faults that we suspect exist, could well be modeled if regional studies of a more comprehensive nature were undertaken.

So far, it appears to us as though the main characterization of this will be

directed towards studies of quaternary faults within the region.

There seems to be little attention or significance attached to the studies of broader or older features of the type I described.

DR. DOMENICO:

Well, it seems that the cost of collecting additional data should be proportioned of the certainty that might remove it or seems like you'll always have a certain amount of uncertainty with the characteristics.

MR. SCHWEICKERT:

On the other hand, it seems to the State that it's important to minimize the uncertainty, particularly as it impacts on the ground water flow model and as it impacts the question of volcanic hazard or seismic hazard or deposits or hydrocarbons because of the complexity and I don't think you can argue that we should stay away from this simply because we'll never know for sure.

I think it's incumbent upon us to reduce that uncertainty.

DR. CANTLON:

You estimate how many years you're visualizing to bring that uncertainty down to where Nevada would be comfortable?

MR. SCHWEICKERT:

At the present, I don't think it's possible. We think effort needs to be directed in that area and so far there seems to be no effort direct in that area other than what the State is conducting now. Thank you.

(Whereupon John Bell takes the presentation podium at 11:00 A.M.)

MR. BELL:

I'm John Bell and I'm experiencing a slight bout of laryngitis, so you'll have

to bear with me.

I guess I'm going to be addressing technical concerns we have regarding prodinary faulting at the site itself and based upon a synthesis of existing work, DOE work and its contractors as well as independent research that we have been conducting over the last several years.

The principal concerns I'm going to be talking about are these; first and foremost we are concerned about the presence of quaternary faults at the site based upon the criteria listed in 10 CFR, 10916, the presence of these faults is a potential adverse condition and may be disqualifying conditions.

I'm going into the paleoseismic history of the faults, their behavior, what it has been during recent times and the need to apply regional and national and help us understand the behavior of faults in the Yucca Mountain area.

The couple processes that we believe need to be assessed are intimately tied to the faulting and then finally, how to interpret future events based on knowledge of past events.

There are numerous quaternary faults at the site which are potentially active and in response to a previous question earlier this morning, depending on whose definition you'd use of active fault, some or many of these may be characterized as active and some have been identified as being a palsing aging that have moved within the last 10,000 years.

They have surface displacement movements created or which created displacement at the surface that we can reasonably relate to moderate to large magnitude earthquake surface displacement are associated with earthquakes with a magnitude of 6 or greater.

So, we see an abdundent effort that Yucca Mountain for previous service displacements and we see evidence that these faulting events have recurred consistently on the same fault traces of these faults may be difficult to detect, but

the lack of detection can be attributed to a number of different reasons.

Lack of definition of the faults due to erosion and occurrence in high terrain or smaller vertical offsets associated with it.

There's a number of reasons why it might be difficult to pinpoint existence of the faults on standard aerial photography, so in order to help better detect the faults, we undertook a research project a couple of years ago which employed the use of low angled aerial photography, a specialized technique wherein we view the entire Yucca Mountain area at several different scales or scalous photography involves photograph that when flown during specific times or time windows during the day, which the sun is at certain elevation above the horizon down to 25 degrees, this then allows for the enhancement and elimination of the very subject features that we are trying to detect.

The results of our study have to date shown that there are number of unmapped faults at the site and that follows that there are probably a number of other unrecognized faults that exist at the site and when we suggest that additional area of photograph and ground recognizance is necessary to pinpoint this as well.

Just so that we all know the terminology here. This is just a quick cartoon and I'm sure that this elementary to members of the Board, but a strike slip fault is one classic, one the San Andreas where faults move laterally passed the other block offset superficial features in a lateral sense with very little vertical displacement or more typical is a normal fault wherein the blocks do tend to have extensional nature of movement and slide vertically past other with a formation of a fault and these are associated with a fault of magnitude of 6 or greater.

Perhaps what we are dealing with with Yucca Mountain, is a combination of these two styles.

We also see an oblique slip fault wherein the block moves laterally past each other, but small components of vertical slip are associated and those are the types of

fault that I'm going to being talking about.

This is the current DOE representation of the quaternary faults at the site. This is taken in 1984 or work which was at a recognizant level study.

They acknowledged that at the time they did this, there may be additional faults present, but this is the current representation, however, that's being used, for example, within the site.

DR. ALLEN:

Can you point out the boundaries?

MR. BELL:

This all is Yucca Mountain here. (Indicating on diagram) This is all Yucca Mountain and the Repository is right here. I have the following diagram that will illustrate it quite clearly.

I just wanted to show the existing representation and there's two points that I have labeled, A and B on here that are also on this following diagram, but just for reference and based upon our work and all the work including the aerial photography, this is the distribution of the quaternary faults that we have mapped to date at the site and again here at points A and B, we have shown the proposed Repository.

I need to point out that we placed the portion as a dash line. It has not been studied in any substance in detail and does not show any existence but evidence of existence.

On identification of these other faults, we think it's likely possibly that it will be shown to be a quaternary fault because of its connection with these other faults and I think you can see in contrast to the previous DOE representation that we have a number of unmapped faults, particularly in the southern part of Yucca Mountain area.

I'd like to now go through quickly and I hope the series of photographs that we use to pinpoint many of these.

The first fault we are going to be looking at is right in here. (Indicating) It's in the Topeka Wash Fault originally called the Windy Wash Fault. We believe it's actually more of what is known as the Fatigue or Fatigue Wash System.

This is a copy of one of our photographs that is a broad surface slopping down off of Yucca Mountain and all quaternaryalluvia of areas and ranges cutting across or transacting this surface and you can see a sharp continuous shadow cast by the most recent offset on the Fatigue Wash.

This is the U.S.G.S. trench CF-1 which exposes the fault quite nicely. The representation of the age of this fault or the present representation anyway and based somewhat on Squadly and Hoover's work has not moved within the last 1 million years or so and we strongly disagree with that.

We believe the field evidence both from the trenching as well as from the sharp character of this fault, suggests a much, much younger age.

DR. BARNARD:

How much younger?

MR. BELL:

Possibly 2 orders of magnitude or it's possible, we believe that geomorphic sharpness of that nature can reasonably be associated with the oldest fault activity and flipping back and forth between things. I want to show you these locations on the map.

The next photo is from the Fatigue Wash and the Windy Wash fault area right up in here and the faults are bounding on parallel ridges.

Again, both of these faults the Windy Wash Fault and the Fatigue Wash Fault over here are marked by short continue unimorphically fresh scratches on the alluvia.

Moving along Windy Wash Fault farther south and down in this area right here, the U.S.G.S. has done considerable work in the exploratory trenches across the faults here.

Some of these faults may show better on your handout than they do here. The fault here again marked by a sharp continuous break going right down through here, these are U.S.G.S. trenches, CF-2 and 3 and John Whitney and others have geological surveys that have done extensive mapping of these trenches and identified something on the order of 7 quatinery events, 4 of those events occurring, they believe, in the last several hundred thousand years and they inquire

an average reoccurrence interval from 75,000 years to the most recent displacement dated less than 3 to 6,000 years, so they have subsequent evidence here of the recurrence movement on the Windy Wash Fault and most recent movement to be in Holocene times.

DR. LANGMUIR:

Where is Yucca Mountain in relation to those fault traces?

MR. BELL:

This is Windy Wash here and it's one of the major faults to the western flank. The next slide I'm going to show you is this prominent fault right here. (Indicating)

On the Solitario Canyon fault which is a major fault bounding the west or western flank of Yucca Mountain, here it's highlighted quite sharply by again a very fresh sharp scar which can be traced quite a way.

This is the U.S.G.S. trenches.

This fault represents now, not having moved in the last million years or so and again, as with the Fatigue Wash Fault, we believe the movement has been much, much younger based on stratigraphic evidence of this trench and based on geological evidence of young Holocene deposits in this scar area.

You can see an unmapped area and this is one of the faults that we picked up and you can see the volcanic branching off and up north, you see the tail end of Ghost Dance Fault as this sharp line and Ghost Dance is the principal fault transacting the

Repository.

DR. ALLEN:

Not necessarily offsetting the - -

MR. BELL:

No, right.

Closer to the Repository, the BowRidge Fault is located on the west side mid-way valley, but it's last break is represented by a thin dark line extending through here. This is trench 14 and the U.S.G.S. has put in and they estimate the last movement in this fault as being greater than 40,000.

Finally, the Ghost Dance Fault itself which is right in the Repository area, has not been found to date anyway, although I need to say that I don't think it's been adequately studied yet, but there's been no obvious indication of offset of material on the Ghost Dance Fault, but is markably extremely sharp alienation or bedrock alignment in the fault and if you are cutting up through here, this is the approximate location of the exploratory shaft site.

So, that's a quick run through of the major faults that we see at the site. Now, as far as what we need to know about them is classified as category paleoseismic history.

First, we believe there's a substantial or substantial evidence in faulting or of faulting in Yucca Mountain and has been complex and distributed involved not only independent movement of these faults, but probably involved simultaneously or simultaneous rupture of the faults, but they move in some sort of a connected method.

We need to know more about this faulting and as I pointed out there's strong suggestion that most recent movement on these faults is significantly younger than presently represented.

The work done by the U.S.G.S. on the Windy Wash Fault, I think

demonstrates Holocene (pho.)activities on that particular fault and I think additional work recently of that fault may be seen on others based upon geologic evidence.

Quickly, based on the geomorphic evidence, these are the faults that we have identified as having relatively young scars and I'm not going to attach a numerical age to these other than to say that they may be related to Holocene activity and they are geomorphically fresh and geologists reasonably have called it a recent surface displacement and these are shown in the dark lines here. (Indicating) We also need to know in addition to how recent the movement has been, we need to know the exact timing of the quaternary events, what that has been and all previous events.

This little cartoon is just to illustrate what we need to know and what has not been determined yet.

An older event for example, offsets this lower unit 22B with the formation of a surface scar. Its trunk indicate in some very date, the age of this previous event and we need to numerically date these two deposits and date or the dating that has been done, to try and constrain these events which has been inadequate.

We also need to know or make estimates of what the magnitudes of the paleo events has been. We believe that based on preliminary data such as looking at length magnitude relationships and by applying regional analog comparisons that magnitude of 7 or greater may be possible for the Yucca Mountain fault and we also need to know what sort of a strike slip component is there.

As Richard Schweickert pointed out, Yucca Mountain lies within the major fault system and we need to know what kind of a strike slip component or components are involved, so that we can characterize the total amount of slip that has occurred on the fault.

Geologic and seismologic evidence indicates that there's some significant components of right slip. This is taken from Roger Angery (pho.), 1987 paper showing focal mechanism within the Nevada Test Site area.

That Test Site border and Yucca Mountain is right about there. These beachballs as they call them, are solutions to the seismic rival at different stations and by looking at the focal mechanisms, they can interpret and there's always two solutions that they can interpret based on comparisons with the regional geologic fault pattern that predominance here seems to be north south trending with no plain with right lateral components indicated by the right quadrant here in that position.

So that you don't see a lot of evidence of normal slip, but you see significant evidence of oblique right slip. So, we think that the right lateral strike slip displacement still needs to be better resolved.

Finally, since that situation with all of this data is unnecessary to understand what's going to happen with future events and we believe that reasonable conservative systems should be used and in a quantitative sense I guess a generic sense, we need to for example, if we reasonably infer a magnitude of 7 or greater on earthquakes from the geologic evidence and the seismologic evidence, we believe that's a reasonable value that needs to be concluded from the assessment of the events at large in this basin.

In fact, I'm going to talk about this part here. We need to use regional analogs and principal analogs and we think the 1983 Earthquake Magnitude 7.2 to 7.3, that it's very similar in structural tectonic setting to Yucca Mountain and lies within the Walker Lane as was pointed out and we have all of those compartmentalized segments and have similarities.

Yucca Mountain is in a different segment, but strikingly similar to the Cedar earthquake.

DR. CARTER:

What distance is this Cedar Mountain from - -

MR. BELL:

It's a couple hundred kilometers. This is Yucca Mountain here and Cedar Mountain is

here, up near Tonopah. We feel there's similarities because both areas have strong indications of strike slip components and north south faulting within the, and the faulting is distributed or distributive in nature and with small vertical displacements.

This is a map of Cedar Mountain that we have been working on and again, with prominent northwest striking faults, the Walker Lane and the Hatchered Faults are the ruptured or ruptures associated with the 1983 earthquake that occurred in a zone about 7 kilometers long and widely distributed fault scattered throughout that area and the faults were north south and orientation left steeping in an echelon and it wasn't on a single fault break, but it was scattered throughout a wide area with vertical displacement which were on the order of 30 centimeters and laterally.

We also believe that there's a need to consider a couple processes and in particular the linkage between the volcanic processes and faulting and hydrologic effects of faulting.

There's been substantial body of evidence indicating that volcanic activities and faulting at Yucca Mountain occurred simultaneously and presently based upon work done by the U.S.G.S. which they have found volcanic ash contained within fault zones.

In the fault zones or the actual fault or faulting, they trace 4 different faults at Yucca Mountain. These are locations are shown here. (Indicating) And a trench of CF-2 and 3 on Windy Wash Fault and trench CF-1 on Fatigue Wash Fault and trench 8 on Solitario Canyon and trench 14 on the Bow Ridge Fault and each one of these trenches, there's loose volcanic ash in the fault zone indicating that a fault ruptured and was open to the surface at the time of that volcanic eruption which is a very reasonable interpretation.

This suggests two things to us, one that the volcanic ash erupts or eruption was occurring simultaneously with the rupture on these faults and they were open and the ash flow.

Secondly, it also supports our contention that faulting here has been

distributed in the nature or in nature and the fault doesn't just move individually.

They move together and the fact that all 4 faults apparently contain the same ash, which we believe may be as young as 25,000 years or so or less depending upon what final age is determined for the youngest eruption from Lathrop Wells, from which they came which is located on the south side of this map.

Also hydrologic effects associated with moderate to light earthquakes are quite common as illustrated here and we are taking some water level figures from a study in the MRC on compilation of water level effects.

This is related to another sequence of large magnitude earthquakes in 1954 at Dixie Valley of 6.9 to 7.1. I think this is the full range here and depending upon how the wells were scattered in the fault and no change in significant rises and significant declines.

We also believe that it's important to consider the shattering effect that occurs when there's faulting taking place.

The faulting events are not clean pristine slices cut into the deposits, but there's a lot of fracturing that accompanies the faulting and in a study we have been doing in the greater flat area, this is the Fatigue Wash Fault and the U.S.G.S. trench C-1.

We have been mapping the fracture pattern here and some of these are shown by the solid lines referred to as fractures, but we have taken a lot of field data verifying the fact that these are fractures in the quaternary alluvia that tells that it's associated with a quatinery vent and also highly suggestive of the shattering that accompanies the faulting by the connections between various faults which we think needs to be a consideration when assessing potential pathways for water movement in both the unsaturated and saturated zones.

So, to summarize the major technical concern on the quaternaryfaulting, we are presently concerned about the existence of quaternary fault, seismic genetic faults at

the site and we need to know more about their style, age, magnitude, events associated with the past with these faulting events.

We need to apply regional and national help to help us better understand how these events took place and how they take place during the future of the pre-enclosed closure period.

We need to assess a couple processes that are tied to the faulting and such as volcanics and finally we need to synthesize all this information in terms of what future events at the site may be.

We believe in doing this, it's necessary to utilize what we would characterize as reasonable conservative system.

I think on that note, to end with here, I'm afraid that the present course that's being taken for characterization of future events may not insure reasonable conservative system. I believe that the, for example, the I believe that the, for example, the use of the DOE"S proposed use of the 10,000 year cumulative slip earthquake, is a non-conservative approach. It's not standard and could significantly underestimate seismic hazards of the site.

So, to end, I'll say that we believe a reasonable conservative system should be implemented in determining both past and future events at Yucca Mountain. I'd be happy to answer any questions.

DR. CANTLON:

Do you assume that the faults are in locations where infiltration has been placed down toward infiltration materials?

MR. BELL:

I assume that, yes.

DR. CANTLON:

And if layers of volcanic ash are put down on the surface, they will move

down over time, why do you assume that there's ash in a fault if there's a simultaneous event between this event and the penetration of ash into the fault?

MR. BELL:

That's obviously interpreted, but based upon what our knowledge, however limited it may be of geologic processes, we believe it's highly unlikely that the ash will be deposited either in this great enough thickness or be deposited and preserved on the surface for very long geologically period of time, so I guess in a sense, I'm not saying that was the same day event, but it was close enough in geologic times that we'd call it a simultaneous geologic event.

It's very difficult to conceptualize any process wherein that ash could have been laying on the surface and stayed there for a few thousand years.

For example, before it was washed down into the faults, we'd see it in stratigraphic sections, you know, I think that that's a, like I said, based on our knowledge of geological processes and erosions and that's a very reasonable interpretation.

DR. CANTLON:

If ash moves down in a fault and you have a bed of ash anywhere, you're dealing here with extremely fine particles in many of the ash faults - -

MR. BELL:

These are probably sand size.

DR. ALLEN:

I don't fully understand how you're concluding in two or three sentences, are you saying that you don't think the 10,000 year period is sufficiently conservative? I didn't understand that?

MR. BELL:

No. I'm saying that the tool that the DOE wants to use to characterize the faulting at Yucca Mountain is what they determine as a 10,000 year cumulative slip

earthquake and I'm just saying that we disagree with the use of that tool.

It's non-conservative and not a standard approach and if I estimate, we can go through the definition if you'd like.

MR. ALLEN:

That's probably not the time to do it, but let me ask you one thing; your studies of Cedar Mountain earthquake, to what extent did those many, many breaks that you have indicated, did they occur along pre-existing paternally existing breaks?

MR. BELL:

Yes.

MR. ALLEN:

In every case?

MR. BELL:

Yes, I think most of them, yes. We have trenched or we have been doing research on the fault zone and trenched in a number of places and there's definitely evidence on the same fault, yes.

I think on the whole, the majority or I mean, we haven't verified every rupture that has occurred on an existing paternal traits, but I think that's more or less true.

DR. ALLEN:

If it turns out that the degree of activity of the faults in the site area is important to the licensing and if there continues to be major differences of opinion between yourself and the U.S.G.S. on these trench interpretations and so forth, I think this is something that our sub-committee ought to look at in greater detail, not now would be the time to do that, but certainly if that remains an issue and I think we have to take a much larger look at it.

DR. CORDING:

You have noted the fractures in the vicinity of trench CF-1.

How did you map those fractures and more or less the northeast or northwest trenches here?

MR. BELL:

The one shown as a map aerial photograph or photography have limits based on the aerial photographic criteria and we could reasonably interpret to mark a fracture of some sort we feel will verify a number of those using the field measurements as a fractural representation.

DR. CORDING:

So, it's the field verification?

MR. BELL:

Yes.

DR. CORDING:

Did you see evidence of the or you have the low angle photos in the vicinity of the exploratory shaft site. Did you see evidence of the so-called unnamed fault which is described in the State of Nevada literature?

MR. BELL:

Are we talking about the northwest trending fault?

MR. JOHNSON:

No, I think we are talking about the fault that we had recently identified from the U.S.G.S. literature.

It's a very - - it's very near the proposed exploratory shaft site and I don't think specifically we have now gone back and taken another look at the low sun angle photography specifically to look for evidence of that particular fault.

DR. CORDING:

It's on that photo, that low sun angle photo that would cover that site, the one that you showed with part of the Ghost Dance, which showed that and I believe it's the

same location?

MR. JOHNSON:

It's in the same location.

DR. CORDING:

On the same photograph?

DR. WILLIAMS:

What criteria are you using to judge the significance of the distance of a fault from Yucca Mountain? In other words, how close to Yucca Mountain does a fault have to be to really be significant and what criteria do you use to make that judgment?

MR. BELL:

We are not specifically addressing the related effects of regional faulting for example, in the hazard areas, so we can't list any criteria and by that standard that we are saying is that the fault's within what is determined a geologic setting are important in helping us to understand what the faults of Yucca Mountain are going to do.

In that sense, we feel it's justified to log and like the 1983 Cedar - - the 1932 Cedar Mountain earthquake definition that NRC may use to anticipate or unanticipating events and process would fall into that category.

You know, you look at those structures that can be reasonable well associated for or provide us with reasonable evidence of what faulty behavior of Yucca Mountain would be and of course, you worry about that or you worry more about the seismic character of the fault at the site from that standpoint and those are the faults we are worried about.

DR. WILLIAMS:

Part of the criteria you have listed is being significant to faulting is hydrologically, in a general sense, what you say is hydrologically, only with the faults that's in this block are significant.

MR. BELL:

I don't' think I - - I can't comment. I really don't work in hydrogeology that much and it's restricted pretty much to active faulting.

I think these faults certainly provide pathways and whether or not they are major regional structures, that also do that, I don't know.

DR. CARTER:

But, you are saying that Walker Lane and Cedar Mountain experiences which was 50 some years ago and 125 or 130 miles from Yucca Mountain area, you're saying that's sort of an analog and you're using that because I believe, you projected that you could have magnitudes in or near the Yucca Mountain site? Is that it?

MR. BELL:

Yes. We think that there's, you know, subsequent evidence.

DR. CARTER:

Some of the faults that you either know about or don't know about are essentially an analog for the - -

MR. BELL:

Yes, the style of faulting is similar. You have self-trending faults in this northwest trending and both Yucca Mountain and the fault rupture in 1932 at Cedar Mountain and that's indicative of the present stress regime within Walker Lane.

DR. CARTER:

And that's essentially the southeastern end of Walker Lane?

MR. BELL:

Yucca Mountain.

DR. CARTER:

No, Walker Lane?

MR. BELL:

No, it's called Central Northern Extent and it runs all the way up to Reno, western Nevada.

DR. CARTER:

So, this is essentially near the southeastern end of the fault?

MR. BELL:

Sort of. I think the most recent interpretation at Jack Stewart of it's segments now includes what we'll call a Las Vegas Valley Shears and that pretty much tied together now with the Walker Lane development.

DR. ALLEN:

Have you ever heard what happened at Cedar Mountain independently and you say breaks, there were breaks on previous breaks to the extent of the exploratory shaft and subsequent excavation at the site conclude that there is no displacement within the path units, would that in your mind be sufficient evidence for saying that future displacements during the next 10,000 years will not take place in those areas where you do not have faulting?

MR. BELL:

Well, I guess I have to say based on my limited knowledge, I think that the standard rational for looking at the seismic fault is that you look for, once you know the recurrent movement in a length of time so you can't preclude, I don't think positively 100 percent that these older faults might not move again, but on the basis of probability that I think it would be pretty close.

CHAIRMAN DEERE:

The probability would be low?

MR. BELL:

The probability would be low.

For example, the treasury fault, I agree with Rich Schweickert in a sense

that they are faults.

Now that may be seismogenic, but don't fully understand the geometry or structure, but as far as what is a standard approach is for looking for sources of seismic activity or activity faulting if you will, it's generally been a standard practice to look for quaternary age displacement and assume that that type of activity is representative of the present stress regime.

DR. LANGMUIR:

So your tuffs are unconsolidated and presumably would not retain a fracture zone as much as you have had shuffling or movement which would preclude any motion or movement of clueds through a fault zone passing through the unconsolidated material and I wondered if you would comment on that?

MR. BELL:

I don't know that much about the mechanical properties over the tuffs. My recollection is that even though they are not welding there was fracturing observed in other areas.

You know, the Test Site penetrates the similar units, but right off hand I guess I can't address that question. I don't know about the mechanical report.

CHAIRMAN DEERE:

Thank you.

Perhaps we should continue on so we can get started with the hydrology before lunch.

(Whereupon Martin Mifflin takes presentation podium at 11:45 A.M.)

MR. MIFFLIN:

I'm Marty Mifflin and I will be trying to summarize some, but not all of the State's concerns with respect to the hydrology and its a very complex topic and I have

taken only a certain general tract and in this particular presentation in interest of time.

The State has a number of concerns which were recognized as Carl mentioned earlier this morning and very early on and most of those concerns are as well developed or more so 6 or 7 years later.

The types of concern that we have are basically two-fold. They relate to the capability and methodology available to characterize the Vadose zone hydrology and a lack of a good data base to date based on the efforts that have been made by the Department of Energy.

There's a third concern too, which I'll jump ahead to in a little bit and that is that we are not convinced that the conceptual model that has been proposed by the Department of Energy is a valid conceptual model.

We feel it's based on a series of assumptions that it is not necessarily a conservative conceptual model of hydrology at that site.

One of the types of concerns that we have is the problem of getting a good and representative data base.

The normal drilling methodology uses fluids and most of the drilling that has been done that fully penetrates the Vadose zone in the hazard area have been done and in fact all of it has been done conventional techniques would use water base fluids, so you don't get a chance to see really the detail of any localized saturations.

You always have samples that have been subjected to whatever you're introducing into the hole during the drilling process.

Of concern to us, is that the attempts to use dry drilling techniques to date is only partially successful. There's been two methods, the old which has the capability or demonstrates the capability to date out in the tuft about 400 feet and the reverse circulation vacuum type of technique which is penetrated to over 1000 feet, but it's very slow and a large diameter and very costly and has been quite a few problems with the whole stability

and so forth.

Two holes were drilled and that technique is using one and using six and there has been no release, at least of water chemistry data from the saturated horizons that have been encountered.

We don't know what that means, but so far there has been saturation encountered in the drilling program.

So, there has been some release cutting where water was squeezed from the matrix and partial chemistry data is on that.

We feel that when we are drilling with fraction network, that that water chemistry and isotope hydrology is probably very useful measure of trying to determine rates of movement and fluids and whether it's fracture flow or matrix flow and we feel that this is a program that has been to date at least, very remiss in developing that type of reproach to characterizing the data on hydrology.

DR. DOMENICO:

Are you suggesting that the data exists and has not been the released or is that the data to the - -

CHAIRMAN DEERE:

The particular - -

DR. DOMENICO:

Are you suggesting that it has not been released or has not been collected?

MR. MIFFLIN:

I don't know. I'm suggesting that there has been some samples taken from saturated cores removed.

I know that part of the State's program observes wet core coming out of the hole and we know that usually when it's encountered you stop the drilling process in an effort to cement off the zone and interpretation was made or that was made at that time and

it was that it was a zone saturation from drilling fluid from nearby exploratory facts.

At one time there was - - it was mentioned at least verbally that they thought there had been samples taken, but later on no samples showed up and in another hole, there was a zone that was pumped during drilling.

Drilling stopped and it was pumped because it was noted that there was saturation and there has been no release of that information or even an indication of whether or not that or what the chemistry was in those pumps and samples.

So, there is some great uncertainty in terms of what's been released as to what the water chemistry is of any of the saturates.

One of the other concerns that we have is not so much with dealing with the program, but with the nature of the site, there's a very high degree of fracturing indicated by the analysis of core data and also bore hole logging or the T.V. logging and so forth.

In fracture intensity we'll go into another slide a little later, but it indicates that fractures are just not in the underrated welding job, but also in the so-called Vadose joints and of course, the high chronologic elements of those fractures is key to isolation.

Another important concern that we have is that in the welding of high highly integrated units involve Repository horizon for example, the welding unit standing on Wednesday.

The Las Vegas Laboratory data which is not very abundant or clear in terms of the way it's presented, indicates that there is hydrologic activity and what that means is that the hydrologic activity, this is one of the points that there can't be hardly any flow in those unites.

There's just too low of hydrologic conductivity and if there's any flow at all, it's going to be fracture flow in those units.

Another aspect of concern to us is based on the section or sectionizing of data base which is relatively moisture content and this raises a question of where this

moisture will go when we input waste and create a thermal level that goes over the 95 degree temperature and there's moisture there in storage and in the matrix and perhaps in the fracture, but we don't know.

The moisture has got to go someplace.

The other concern is that on the bottom, the saturation has been encountered and if it indeed is related to the natural processes rather than fluids indicates clearly that there is active flow and you can't have saturated fractures on fresh water without actual flow. One of the parts or key parts in fact, the absolutely critical part of the proposed conceptual model of the site is that they have low flex, unfortunately and an arid zone hydrologically, we don't know how to measure recharge.

There are very good techniques on a site with specific basis for terrain style basis and there's very little information or methodology that has been demonstrated that pins down what the recharge is.

In a very confident matter, we do know that there is recharge in these areas or semi-arid climates in the sense that we have activity and dynamic explosives and we can see in some areas that we have environmental traces that indicate for example, tread deism getting into the system, but on a very specific basis such as Yucca Mountain, there hasn't been demonstrated any confident methods to determine the initial amount of recharge in a quantitative manner.

The conceptional model that has been favored by the Department of Energy calls for a very, very small net recharge, no more than 1 millimeter.

We can't say that that's wrong, but we can't say that that's right with the available methodology data.

One of the problems with it is specific recharge, is that rather than an attributed function in time and space, it's more like in terms of availability moisture in time and space and hydrologicalized in terms of local environment such as washes and also

highly restricted in terms such as a few weeks or a few months, depending on what we are talking about.

So, that a distributed recharge flux, at least near land surface is highly unlikely.

It's more likely to be localized with both time and space, but we are talking about that, if it is true that it's a one millimeter per year on the average, it's more likely in a localized environment of 10 or 15 or 100 millimeters per year or per month or whatever they turn out to be in terms of recharge event.

There is some data that has been presented by the U.S.G.S. and the key units are the saturated zones start down in this unit crater flat unit and this unit here contains a proposed repository horizon, not the proposed units but as we get into the so-called bedded or non-welded unit, the Calico Hills has already been or hasn't been mentioned, but there is a key unit with respect to travel time consideration.

It has a higher potensity and notice the saturated hydrologic conductivities that have been reported.

I will go in to these in more detail in the next slide, but we have very low, less than 1 millimeter per year for example, for the Tiva Canyon.

We have 1 millimeter per year and then these others are high and several orders of magnitude higher.

There's an interesting contrast in Calico Hills. The vitric or the unaltered ash has the saturated and the altered part of it has a much lower hydraulic conductivity.

This is called, as I mentioned, our concern with respect to the moisture that's in the matrix for storage. These are the percentages of saturation and notice in this one, this value is 65 percent.

Of course, this is very high and in fact, these values here are very similar to values that come out of a saturated or a sample that comes below the water table.

We have fairly high moisture content here and we do have water in these other units. This is the same type of unit involved here that's a little bit of an analysis or simple minded but very important to the question of waste isolation and travel time.

These are different values that are in the literature and these are the sources here and none of those values or none of those reported values actually are the laboratory values.

The laboratory data sheets have not been published other than in a data bank that we don't have a tape of.

This particular one right here, (indicating) but these are the range of values that are shown up in literature and kind of give an idea that depending on which method of interpretation or statistics that have been used, the numbers jump around.

For this purpose of this argument, what I have done is based on an annual recharge rate and contributed over time and space this little analysis that shows whether you'd have fracture flow or matrix flow and assuming that the recharge rate is less than saturated hydraulic conductivity of the unit, you'd have matrix flow.

In other words, you can handle the water coming in and flow by matrix. However, if you have more water coming in than the hydraulic conductivity of that rate, then it has to slip off into the fracture.

So, this little MF analysis shows if we have 1/2 millimeter per year for example, here of recharge, we'd have either depending on which value you like over here; matrix or fracture flow and keeping in mind these values are not but these are some type of a statistical representation, so we have lower values and higher values.

DR. CARTER:

What's the reason for the tremendous difference? Some are factors of 2 and others are - -

MR. MIFFLIN:

I don't know because we don't have the data. Anyway, part of the problems is that these types of methodology are variable and therefore, depending on how you or what type of example you took, you would vary the result in terms of the values you get out of a lab test or testing.

DR. CARTER:

There must have been a lot of differences.

MR. MIFFLIN:

Imagine the welding of this, where its plastic fragments as well as glass shard and if you have a pumice fault and you have to take a little wafer for your hydraulic conductivity, that overlap or the pumice fault which has hypopensity, proposity and higher hydraulic consult than not, it's been welded into a solid mass and you'd get a different value.

If you have a micro-fracture that you didn't see and have low glassy style comes out little micro-fracture might also affect the hydraulic conductivity.

DR. LANGMUIR:

You said earlier that you lacked geological data on the conductivity. You're showing a reference of values.

MR. MIFFLIN:

These references are of this one and I assume on some type of data bank board system and it probably has the full value, okay?

I don't want to have that be that these two references on those values reported in the environmental assessment and the U.S.G.S. publication such and such give only the, for example, this one is a, if I recall correctly, a geometric means.

MR. LANGMUIR:

Have you asked for the detailed data and not been able to get it?

MR. MIFFLIN:

Not directly to the people who produced it. I think that State has asked for -- I don't know, Carl did we ever ask specifically for it?

MR. JOHNSON:

Yes, we did.

MR. MIFFLIN:

We asked for a lot of things and there's a laundry list and it's hard to remember what we have asked for.

A little more elaboration to your question. I don't think it's in some cases, necessarily a withholding of information, but a lot of times it's hard for the DOE to find it, but in some cases because of the way in which it has to be found, in other words, to go around through the official channels, why it takes a lot of time and we have received data that has been requested but not everything, but there is a problem, I think in terms of the amount of data that actually exists and is reported in terms of these values.

Anyway, to complete this picture, we see that we could have fracture flow and we have, say a millimeter or more recharge in any localized spot on the repository and we should have fractural flow in Tiva Canyon.

If we believe there's no fractures here that are quite open, we should have matrix flow in the unwelded part in the tuff and we get down to the Tonopah or Topopah Spring and I think we have fracture flow here exclusively.

It's not the highest value that counts, but it's the lowest value that tells you if it's a bedded unit so to speak or a horizon.

It's a lowest value limits or whether or not its gone by matrix flow.

In that sense, I think it's more likely that if it's influx at all, it's fracture flow and when you get down into the Calico Hills, it's according to this interpretation, if it's a vitric part of Calico Hills, it could be all matrix, however, if it's unwelded, I mean, unwelded geolectric, it could be in the higher flow range or fracture flow.

This is the unit based on the SCP that is T to travel time. I created this because too many of the people in the program don't seem to be field geologists and I wanted to exaggerate what the fractures mean that had been reported in the data base and the analysis of core and what we did is we created a little exercise that measured the thickness and the area extends to establish the volume of one of these units under or within the repository block.

In other words, each one of these units within the repository block was determined with respect to volume, total volume of rock and then based on the drill core analysis of a number of fractures per cubic meter, we made out to establish how many fractures would be in that unit within the repository block.

We see for every unit, we have a billion fractures and that's important because we have probably distributed sources of recharge over part of the repository block of the land surface.

In any part of the repository block, we could have different conditions in terms of characteristic factors and they fluctuate.

DR. CANTLON:

Are all the fractures vertical?

MR. MIFFLIN:

No, they are but I think it would be safe to say that every non-fractured cubic centimeter of material that is in the repository block from top to bottom is bounded by fracture.

DR. CANTLON:

Of one dimension or the other?

MR. MIFFLIN:

Probably hundreds of thousands of variations of terms of actual characteristics of fracture itself, but this particular diagram is of the proposed conceptual

model, the conceptualization is briefly that in these embedded units, there's a higher hydraulic conductivity and probably matrix flow and some type of a lateral transfer of lateral flow of the water and that kind of bounds up there because it's a hydraulic conductivity to major zones where it goes around the majority of the repository or say down along the fault zones.

The same thing, these little squiggly arrows are going out is a vertical vapor block and these darker locations or zones conceptualize possibility of fresh water associated with the changes in methodology.

I think the point I would like to make is and the very important point is that even the bedded units are fractures and those fractures in those bedded units have not been established and if there's fracture flow for example, in the Calico Hills, then travel times becomes relatively short and when I say relatively short, the travel time from say the repository horizon and this zone to the saturated zone down here, could be, depending on the characterization of the practice, could be days or weeks or years or hundreds of years or thousands of years.

DR. LANGMUIR:

Aren't these fractures really microscopic fractures?

MR. MIFFLIN:

No.

DR. LANGMUIR:

What are the scale or dimensions of them, if you took a distribution of them?

MR. MIFFLIN:

There isn't data on that where I have seen welded tuffs and bedded tuffs exposed, but typically there's a variety of fractures in terms of their apparatus and so forth.

On surface exposure, you might have to be a little uncertain as to what you

are seeing because of what the surface affects of relaxing the stress is so to speak, but in the subsurface for example, in tunnels in this mesa, you can see the fractures and they vary in terms of characteristics and in core.

You have incomplete core recovery and you'll have the tunnel zone in some areas, so fractures are highly variable in terms of degrees of their openness or characteristics.

DR. LANGMUIR:

Wouldn't they show evidence though of historic movement of water and through changes in chemistry?

In other words, the mineralogy would have been changed with movement?

MR. MIFFLIN:

Some fractures have secondary minerals and in fact, the fractures in this particular unit here in an area where I have looked at, there's fractures of calcite for example embedded or in the bedded unit.

DR. WILLIAMS:

Based on data from saturated zones, don't you think you're worried about faults rather than fractures?

That's what you have drawn there.

MR. MIFFLIN:

This is highly idealized.

I think if you go back or consider what was being said this morning in terms of the tectonics style as you go back and read carefully, Scott and Buzz, you look at what he thinks in terms of what are really fractures and what are really faults and where you'd get exposure.

He mapped a whole series of parafracture plains that he thought would demonstrate in some cases and where actually had faults or lateral displacement of a few

centimeters to a few meters where he had some type of stratigraphic control.

So, I think there's faults and there's faults and there's faults and their fractures and if you separate them out in this particular case, maybe somewhat different than other types of methodologies where the faults are the primary actor in a sense.

DR. WILLIAMS:

Item 131 saturated zones tell you that a very small percentage of the bore hole would be supplied.

Why would you expect it to be any different or why would it be any different than the unsaturated zone?

MR. MIFFLIN:

I think that if I personally think that it's not just the faults that are carrying water and I think that's the case, but I don't know, nobody knows, because the data base is insufficient to demonstrate, but I think that if you want to find or there is a data base developed, that both fractures and the faults will carry the or any fracture will exist and you and I disagree on that.

DR. CORDING:

Would you clarify what is a fracture and how is it observed if it's from the core log?

MR. MIFFLIN:

These values or that this value right here and here, those values are based on examining the core and counting the number of fractures that the individual's doing the exams judge not to be caused by the coring processes itself and translating that into a number of fractures per cubic meter.

DR. CORDING:

So, the one with the one fracture from the core which is deemed to be a natural or pre-existing factor and or orientation of that could be any orientation horizontal

or a lot of them with the bedding because of the natural weakness along the bedding and other or others may have been high angles; is that correct?

MR. MIFFLIN:

Whether it's on bedding or not, I don't know because the bedded units normally do not have clear bedding apart from - -

DR. CORDING:

That would be a preferred orientation somewhat distinctly or distinct sections?

MR. MIFFLIN:

And the other problem with this type of statistic is that core only goes in one direction and therefore, the probability of intercepting some fractures if they are parallel, any of the fractures that are exactly or their plain is parallel to the core, you'll never encounter core and then we don't know the continuity of those factors beyond the bore hole itself where they are extended from one foot or 10 feet at least it's not shown in that statistic there.

The other thing too, is that the criteria is; we don't know how much for example or whether these are the real big obvious factors or whether they are all small fractures which were counted too.

DR. CORDING:

I think in terms of a reference when we look at fractures which are in the range of 4 fractures, 2 fractures or 1 fracture per 10 feet of core, we are talking about generally about what we might describe as excellent quality rock and there are very few fractures compared to most geological formation and I think depending on the way you calculate it that it would sort of be the trend we are seeing.

MR. MIFFLIN:

I wouldn't disagree with you, but the point is that, the fractures are there and

if you examine licensing criteria and or how the hydrology behaves is that that is what counts.

DR. DOMENICO:

Does your conceptual model here differ from the DOE's only in the magnitude of the hydraulic conductivity that is assigned in various units which will conduct the flow of the matrix or the fractures?

MR. MIFFLIN:

My conceptual hydraulic model is one of the following, the infiltration is not uniformly distributed in time and space, but it's highly concentrated in space and time, therefore, the upper part of the flow field, you have fractural flow and the other difference in the model and I don't think there's very much lateral displacement and I do not think there's capillary barriers that actually work as

you go from one flow unit to another.

I think that a concept work only on a very short - -

DR. DOMENICO:

How many of these if any, will be resolved with exploratory shafts?

MR. MIFFLIN:

I don't think any will be resolved with the exploratory shaft because from the standpoint of travel time calculations, because it stops before it gets to the Calico Hills and all travel time calculations are going to be from here in terms of flow.

In terms of gas flow, that's a whole other story.

CHAIRMAN DEERE:

I'm going to ask that perhaps we can take a break now and we all need it.

If we can come back and put that up again and your two summary slides because there will be more discussion.

I don't want it to run over 10 or 15 minutes, but I have announcements and

the persons who are going to the Yucca Mountain trip on Wednesday who wish to have lunch, they should sign up by 3:00 P.M. today at the table in the lobby. The cost is $4.00 and exact change preferred.

Today at 6:30 we'll have a no-host reception here in this room or the adjacent room at 6:30.

We'll take a 1-hour break now or 1-hour and 5-minutes if that's okay and be back here at 1:30.

(Whereupon the meeting was adjourned for a luncheon recess at 12:35 P.M.)

(Whereupon the meeting was reconvened after luncheon recess at 1:35 P.M.)

CHAIRMAN DEERE:

We left with that slide still showing and in case anyone wants to have more questions before we go into your last two presentations, so I will ask for any questions from the members of the Board or consultants, if there are any?

MR. MIFFLIN:

No questions.

In summary, based on what I have tried to present, it seems reasonable to predict that fracture flow should occur in at least some units that are highly welded if we have any type of localized or even well-distributed annual fluxes of more than about a millimeter or even 1/2 a millimeter in some units, so we think that's it's reasonable to predict that first water and fracture flow does exist and in the Vadose Zone.

If this is true, it cuts down on travel time very significantly. We are talking about the possibility of two types of flow regimes and one could be open channel type of travel flow fractures and the other could be more of a saturated porous medium, both probably occurring in fracture terrains where there is fracture flow.

The complexity of this site is clear on the basis of variations in low conductivity for some units and the higher hydraulic conductivity in terms of matrix measurements and other units.

The fact that there is also the vapor transport that is involved where the geothermal grading is upward and the vapor flux would be upward also.

The one point that I forgot to mention and is quite important with respect to the question of degree of waste isolation for a site is not only do we have to worry about the liquid fracture flow in the downward sense, but we have the same fracture network operating for an upward flow of soil, gas or whatever you want to call it and after the placement, any types of gaseous radionuclides such as carbon 14 at another time, we could discuss some of the evidence that exists for a very active pneumatic circulation at the site.

Some of the wells blow and suck air and this would suggest that there is an atmospheric transmission on a very short term basis to a fairly deep level in the Repository section and the bedded paint brush tuff or that bedded unit above the Repository horizon which is welded at Topopah Springs is also a key unit with respect to whether or not fractures are highly connected to that unit for the circulation of soil gases.

If so, there may not be any containment on the top side either, so if that's the problem to worry about and also characterize, there is that problem.

In summary, I think that the point the State would like to make is; arid climate doesn't necessarily insure that there's no water around for recharge and it doesn't necessarily insure waste isolation.

This is the concept that it does, but on close examination, we think we find no satisfying evidence that it necessarily creates a situation of waste isolation if you're dealing with the Vadose Zone.

It's obvious that the hydrology of this Vadose Zone is very complex and hard to characterize.

We think it's obvious that fracture flow exists and we think it could be a common process at the minimum in the highly welded units.

So, soil air travel time is a very critical aspect and it could be very rapid and the question with respect to site characterization is the type of pneumatic circulation that it is evident now with respect to the blowing and sucking wells that are in that area and whether or not that process operates to the Repository horizon or not, the data base is not clear.

And the last or the second to the last item is; travel time to the underlying saturated zone could also be wrapped with fracture flow.

The real question is; whether we get a significant travel time through the Calico Hills, these are all matrix flow and if so, I might add with respect to the site characterization plan, how will this be demonstrated on site specific data.

The last one is the type of conclusion that is a very general one and that is, that we really think that if this site is going to be characterized and including demonstrating on a scientific ground that it has the properties of waste isolation and there has to be a very well developed site specific data base established and that does not exit now and in our opinion, it may not exist or seems like it won't exist after or if all of the activities that are sited in the SCP are performed, we are still not convinced that we'd be that much farther ahead.

Any questions?

DR. CARTER:

What about the specific plans that are in the SCP now regarding flow time measurements? To some extent what you're saying I presume is that, that is a very educated speculation as far as what it might be, but there are plans to do actual measurements over the next few years and let me ask your evaluations of those measurements, particularly for flow time?

MR. MIFFLIN:

If you look carefully at the site characterization plans, you will find with respect to the Calico Hills units, there's only 2 or 3 more holes that will penetrate that unit and only 2 of which are on the edge of the Repository block and the others will be 2 kilometers from them, about 2 or 1 1/2 or 2 kilometers.

The exploratory shaft now does not penetrate down to that unit. There isn't plans that I can see that would give and I might point out that the two new deeply penetrating performed bore holes are quite close to the existing UC-6, so we are getting the same samples you might say or the same as in the area of the Repository block.

There's just something in that plan that the comprehensive data gathering plan to evaluate the Calico Hills.

DR. CARTER:

Isn't it possible that you could have a positive result or long flow time before you get to the Calico Hills, as it's quite possible that you could answer the question in the affirmative in terms of acceptable flow time and I'm not saying that's going to happen, but certainly it's a possibility?

MR. MIFFLIN:

In looking at the or if you ask, how will we know, I'm talking about the new holes and how will we know if there's no data base, but the only place that you'll get a chance to look at that exploratory shaft is there.

DR. CARTER:

You may find before you get there that you have to get or accept a long flow time and that's one possible outcome.

MR. MIFFLIN:

Remember the criteria is from the edge of the observing zone to the edge of the desirable and we haven't talked about the undefined area yet at this point in time, but as

far as ground water going down in the Vadose Zone, it would be underneath the Repository at some point.

There is no, at least the way I read it, there is no program that's going to gather data in that area.

DR. CARTER:

We have got to get the water from the surface down through there before we can get to the Calico Hills.

MR. MIFFLIN:

No, the licensing criteria is from the disturbed zone, but the water is there, for example, in terms of moisture content and it's there or appears to be there in a few samples from high moisture content in the Calico Hills, essentially saturated.

DR. CARTER:

We don't know, it's moving.

MR. MIFFLIN:

No, we don't, but we are going to sample that.

DR. DOMENICO:

What's being done on the point of non-welded that you'd like to see done in the Calico Hills demonstrated one way or the other, what is happening?

Is there something being done there?

MR. MIFFLIN:

In the paint brush tuff, there is the opportunity without penetrating below the Repository horizon to maintain the integrity to distribute and to try to come up with some design of what the flux through that unit is and try to determine whether that flux through there is all matrix flow or partial major flow.

In other words, if you went for a program to see how that unit behaves and try to make that an analog of say Calico Hills, you have a much better opportunity to do

that in terms of a drilling program, but that's or the SCP, it will be penetrated at, I think it's penetrated at the exploratory shaft and depends on what the surface geology is there.

There will be some more bore holes around the exploratory shaft and that's it plus the two holes down by the US, that's it.

That's not a very ambitious program when you consider all of the bore holes and data associated with it and it may not meet quality assurance criteria and most of that data was or came from fluid drill, you know liquid type of drilling through it.

The other problem I see in response to the question of how you do it, is; there's a little problem with the drilling technique that hasn't been resolved since that it's still not clear where you can drill in a tricor without heating up the core to the degree that you drive off all the moisture.

The data has been convinced early in the game that there are drilling techniques that are quick and effective, but not for boring, but just for cutting and looking at say pre-water fractures and so forth and we are convinced that that method is good.

DR. DOMENICO:

Calico Hills as well as the greater flats have already been penetrated and you have saturation measurements there; is that comprising or compromising?

MR. MIFFLIN:

The geologic G-1, G-2 and G-3 are a series of geological areas and they have of course, from a couple of sources, those are drilled with drilling fluids and those are the cores that are in question as to where the same came from and so forth or at least some of those cores are.

So, that's where those cores is where some of the values that were put down in terms of full saturation and hydraulics.

DR. WILLIAMS:

I have a question about inhaling and exhaling bore holes.

Has the State monitored or had the opportunity to monitor any fractures that inhale and exhale simply to the inhaling/exhaling bore holes with changes in the atmosphere pressure?

MR. MIFFLIN:

We haven't monitored overtime, but we did make a survey or kind of heat type of test survey and found numerous thermal or several were right along a kind of gray shaded area of one of the major faults on the west side.

We correlated the thermal image from those spots you might say with the temperature H-6 which was blowing at the time and the temperatures are exactly the same.

In other words, on the thermal scan you have got exactly the same temperatures for the rock around the thermal temperature and there were the matrix temperatures of the well head at H-6.

The problem with doing this type of monitoring is that the flow occurs in the late fall and that it's best developed 3 or 4:00 in the morning for thermal imaging, because you don't have any of the solar direct radiation effects on plants and so forth.

So, it's particularly easy to go out there and do it and it's not, but there's evidence that the gas circulation based on our cognizant type of survey does exist beyond the bore holes themselves.

I might point out that the question, you know of what depth is that coming from and because it penetrates into the Topopah Springs.

MALE VOICE:

The question was raised in recent course that I took on Nuclear Waste Management as to a problem that's unusual with respect and unposed, but could be a serious problem and that's the problem of removal of these wastes and should these "waste," become technology useful to the 21st century and I understand that would be a very dirty process indeed, but has there been any thought or work done on this area in

terms of making that process or this potential process less dirty?

CHAIRMAN DEERE:

I don't believe we are ready to address that question here, certainly not at this time.

(Whereupon John Fordham takes the presentation podium at 2:00 P.M.)

MR. FORDHAM:

My name is John Fordham and I am Project Manager for the State program that is being undertaken by the Water Resources Center, Desert Research Institute in Reno, Nevada.

I'll address some regional water concerns related to the proposed Waste Repository at Yucca Mountain and address the concerns and the current understandings of what the Regional System is and then some recommendations as to what we believe ought to be done.

The first concern is; how the Repository itself relates to regional flow systems wherein the or this relates to where the possible contaminants would flow down stream or down gradient within the system and the impacts of the potential or potential impacts that would have on future water supply development in the entire region of Yucca Mountain.

The required analysis is to determine the probable fluid flow taps to an accessible and I want to distinguish that between what is known as the term of, "Accessible Environment," which is 5 kilometers from the Repository site.

I mean, in the actual environment and to have some level of understanding of confidence and this would require a thorough understanding of saturated zone flows system at a regional or sub-regional level and on the site scales along with the approach of DOE has taken so far, essentially are attempts to define the regional flow system which

then is superimposing on the boundaries on a sub-regional system which has modeled and that imposed east boundary conditions
on the site system.

We need to be able to evaluate the pre and post closure system dynamics and this would be increased water usages or irrigation potential and the increased use from mineral or the minerals industry in the area and perhaps an urban water supply for the entire Southern Nevada area.

We have to be able to look at the climate changes and the effects on water levels that could be discharged into locations.

Of course, we have to attempt to be able to evaluate what the potential structural changes in the area might be as spoken to this morning and that we have possibilities for all kinds of changes in the structure.

The current understanding of the regional flow system goes back quite a ways and originally was based on work by Winnegrad and Thorson (pho.) and work by Winnegrad prior to that was probably as far back as 1962 in the U.S. Geological Survey.

That understanding of the regional flow system around NTS and the location of Yucca Mountain was updated and revised by John Sarnecky as an overall regional model as in the 1982 publication that was further refined by - - I'm sorry, it was Wadell in 1982 and John Sarnecky and Waddel in 1984 where they define a sub-regional model and further work by John Sarnecky which took that sub-regional model and made further modifications mostly recently and there's been additional work related to the overall carbon aquifer in the southern part of the state, by both the Desert Research Institute together with the U.S. Geological Survey, which might have some impact on the understanding of how that overall system has worked.

We looked at the overall regional flow system and essentially as defined by Winnegrad, this an 18,000 square kilometer system with flow moving primarily from the

north or northeast to the south or southwest.

The exception of that being, some flow or recharge coming from the spring mountains which moves to the north and then perhaps curve around and moves to the south, southwest.

If you look at this boundary here, we have a number of questions and we really don't understand exactly what is happening say in the area near Indian Springs and the Las Vegas Shear Zone.

There's questions related to how much flux recharge might actually be coming from the north, northwest or from the Paranaget Range.

There are questions as to how much water might be moving from the north of the mesa over and then there's some unanswered questions related to say the discharge to the Death Valley National Monument down near Furnace Creek Ranch.

DR. CARTER:

Let me ask you, I presume that the weapons testing and all of those activities have been going out or going on out there for years underground or uses for ground water; is that correct?

MR. FORDHAM:

Yes, there are all kinds of - - well, there are a number of holes on the NTS that have been developed for - -

DR. CARTER:

Including some springs?

MR. FORDHAM:

There are springs on the NTS, but a lot of those holes that have been dug for the weapons testing, although the number that was developed for hydrologic testing on NTS is probably not as great as you might think.

Most of the original concepts of Winnegrad were developed from the data

that was or is available, but say there's a lot of data up on Yucca Mountain where most of the underground devices have been tested.

Right now, we have a fair amount of data here that Yucca Mountain and the other remaining part of that 18,000 square kilometer area has varying degrees of information that's available.

DR. CARTER

Another question that I had. How far does the ground water have to travel to basically get to where its at the moment for public use and that obviously may change, but as with Lathrop Wells or is that the closest place?

MR. FORDHAM:

From Yucca Mountain which would be this block here (indicating) and Lathrop Wells and the Armagosa Desert, there's a considerable amount of irrigation.

There's some unanswered questions as to what is being developed other than the alluvia as to what really is the source of there.

There are no deep holes in the Armagosa Desert. They carbonate the aquifer system covers in one way or the other and maybe not continuously certainty, but the flow regime is there.

So, that's one of the things that really needs to be looked at is; how that carbon aquifer and the tuff and the alluvia system interact.

If you try to keep in mind where the arrows are here (referring to diagram), you can see and then take a look at - - well, it's rather an old precipitation map, but most of the work was based on work regarding the recharged areas and obviously are to the north and the heavier precept of the Sheep Range and the Spring Mountains and the Paranaget as I said, are up here north of Pahute Mesa and perhaps Gold Slat in Kawich Valley.

The good part of the area that's immediately on the Test Site which would be Yucca Mountain trench shows the actual amounts of recharge are fairly small. This

kind of gives you an idea of the data density and the gradients on a regional basis.

We have fairly steep gradients to the north and steep gradients that have been observed around the Yucca Mountain area and steep gradients in the Spring Mountains and of course, if indeed the discharge around here at Death Valley Monument and extremely steep gradients in that area.

The original work basically broke the overall flow system into three sub-regional systems; the Ash Meadows Flow System, wherein flow is as I said, predominantly from the northeast and your predominant discharge is that Ash Meadows area where part of the Death Valley National Monument is developed holes.

DR. CARTER:

The water comes to the surface, I think, which is on the Ash Mountains?

MR. FORDHAM:

Yes. There's a pretty good discharge area here and it measures something like 17,000 acre feet a year, if I remember correctly or whatever you want to call it, but there's some new thinking that maybe as the Furnace Creek Ranch is out here and on occasion, the valley flow system here. (Referring to the diagram)

The original models that were run basically were parameter estimation models by Rich Waddel which he took the existing data base and backed out the transmissivity values and examined which parts of the system might affect the immediate vicinity of Yucca Mountain, so that by looking at or trying to get a better handle on which potential pieces of overall flow system you should try to tie down better or perhaps some of the flextion that might come around or across on the Paranaget had very little influence over here where certainly, the flux across this northern boundary and the Timber Mountains should have significant affect on what the ground level and flow system in the immediate vicinity of the Repository look like.

To do that, they or Mr. Waddel and Sarnecky put together a model of sub-regional systems, which is the Furnace Creek flow system and the Yucca Mountain or this area here where they picked a constant head boundary like Timber Mountain and the Pahute Mesa and a couple of fluxes from Yucca Flat and going in or from Rock Valley, there's a minor flux or small flux across the boundary from Ash Meadows which needs to be tied down better and then discharges in the Alcolae Flat and the Furnace Creek Ranch areas.

We can look at the data density again and see that you have a lot of information in the Armagosa Desert and some down here in the Alcolae and the Franklin Lake and you have a reasonable amount of information near the proposed Repository and very little information north of the - -

DR. DOMENICO:

Is that a composite section, that's not the same rock unit that you measured?

MR. FORDHAM:

No.

DR. DOMENICO:

Q. So, it's a composite?

MR. FORDHAM:

There are very few that we have measurements of, specific units. Almost all of these are composites and of course, all of these are basically down the alluvia, but up here theses are mostly from the water tables and wells and they are finished.

I don't know how many meters into the saturated zone, but those are composite heads and all of this or these models are two dimensional and you're essentially throwing away of the vertical components and the importance thereof.

Basically, they're conceptual models and now this is from Sarnecky's work,

but they have a constant head boundary across the northern boundary and had discharges and both break away and Furnace Creek Ranch and also John Sarnecky later did exercises in which he was going to evaluate potential changes and he changes these to two discharge areas to constant heads of points and put a flux across the northern boundary so he could play games, or I shouldn't say that, but manipulate his model to stimulate increased precipitation.

We feel what is needed, is a refined or I'd say would be accurate, but it's probably in the eye of the beholder, a refined sub-regional model which you can evaluate all kinds of possible futures.

We need more extensive data base to define what the saturated zone flow looks like and need to get a better handle on the importance of the fracture flow within the saturated zone and the evidence at hand from some of the testings that have been on-going out there and undertaken out there and they indicate that there's significant flow in the or from the fractures that you may basically be able to ignore the matrix and the saturated zone.

As pointed out this morning, we don't know very much about the or how the structure is actually controlling the flow system on regional or sub-regional basis or whether the alluvia are acting as barriers or conduits or whatever and we do need to understand the interaction with the regional carbon system pass as pointed out and most of the information that is available is based on composite heads and analysis and essentially are two-dimensional, so we don't really know whether the water is also moving down into the carbonate system or back up out of the carbonate system or where.

We need to evaluate the way or we need to evaluate the impact of precipertations to the existing flow system or the changes that everybody has been talking about which if the climate changes on or to a wetter climate, it would more than likely result in increased recharge and perhaps rise in the regional water table short and flow

past, but if you look at the evaluation of ground water travel time under some possible futures, you might wind up, together with an increased flux at the site which should go together with the reservoir table and the ground water travel time, which could be quite short.

With the increased regional water, you'd or in these areas, there might be some effects as increased irrigation, although the Armagosa is a designated basin and probably is currently over appropriated, since we are seeing locally water level decline over the last 20 years and that should be evaluated and the effects or the current effects of increased mining operations also need to be looked at.

Bond Gold, I think is supplied for 3200 acre feedout of the Oasis Valley and the Soka Minerals currently has wells or applications for wells out in the greater area and a couple of other mineral expirations or exploration outfits are doing the same thing.

DR. CARTER:

Where are those located in reference to the Yucca Mountain site?

Are these or are they west, south or what?

MR. FORDHAM:

They are basically the west greater flat which is directly west of Yucca Mountain and Bond Gold and their operations are right over the hill from Beatty, just to the west of Beatty.

So, where is Beatty and Bond Gold, the operations are right in here and where is the greater flat, well, some are up here near Bear Mountain somewhere. (Indicating)

DR. CARTER:

Are they in a different water regime than the ones that we are talking about?

MR. FORDHAM:

No. It's all inter-related somehow and that's one of the problems. We don't

understand the connection and we don't really understand necessarily what's happening at the northern end there.

Of course, their probability of structural changes which we talked about in relationship to tectonics discussed earlier today, could wind up with changes that would affect the potential discharge locations and especially at the site changes and those potentials create new barriers and conduits.

I'd like to recommend that they be converted effort to really go back and look at the regional system since it becomes a constraint on the sub-regional system which then provides boundary conditions and constraint on the site system.

When the earliest work really hasn't been necessarily defined and the original ideas that were put forth in the earlier or mid '70's, there are still a number of areas that need to be clarified.

You need a better definition of where the recharge areas are and the questions of what the underflow from the north of the site is and if you look at some of the models or the recommendations were that these are areas of data sufficiently and there are no plans to go back and put down additional holes and fill those indicated fissures.

We also need to understand the importance of recharge from the wash system and not simply the recharge of the 40-mile wash.

There's the Armagosa River and all kinds of other washes out there which Marty was alluding to as far as maybe maybe the primary areas of where the recharge is occurring at the whole area, but to answer questions that not only we have, but questions that are certainly of concern to the National Park Service and there has to be work done to understand the controls and mechanisms and sources of water for the discharge in the Furnace Creek Ranch area.

That's not simply the amount of water that's taken there for use by human consumption, but for the entire environmental region of what those springs support.

We need to understand that some studies need to be done to understand a little bit better the areas of steep gradings and if you'll notice, I left one out, north of Yucca Mountain because that's bound to be or will be a rather extensive or extensively planned by the DOE, but the ones east of Mercury and the ones north of the Test Site, they all have impact on what the regional water flow ground system says is happening and at present your water conditions for your sub-regional and site system.

The influence of the Anisotropy, if I said it correctly the first time, on the local flow pass has to be done and we know that they, or this morning, we noted that most of the fault trends were in the north, northeast and we think that gives us yields, essentially a preferred flow at an area of lesser resistance and the testing for that should be beyond the site.

Currently, most of that work is basically from the C-Wall complex which are 3-wells on the east side of the Repository drilled back in, I think 1984 and that should be expanded a little bit more than the southern state, at least the sub-regional system for a better understanding of further downgrading.

I think what is eluded to here is the vertical 3-dimensional model as proposed to be used to evaluate such things as additional pumping and climate change, but it's basically proposed to be based on existing data and very little in the way of the actual 3-dimensional information as far as what the gradiance are.

They have H-1 shown in an upward gradient and P-1 at the site, which shows and upper gradient from the carbonates to the tuffs near the site.

There are a couple more holes which would be proposed and could be deepened to the carbonated in WD22 and 23 which I think are the great flat which would or should add to that data base, but essentially no information on the 3-dimensional and the vertical grading to the south where the flow system is moving.

And then, we need a thorough evaluation of what possible or probable, I

guess I should have used, future conditions which are the ones that we have revised the models and the one or the models are revised and as an example of why you should be concerned is as an example, that those are pulled from Sarnecky's and I don't know whether we should call those 4, 84 or 85, but I can't remember the GS designation, but it's 84- something or another which he took his sub-regional model and postulated a 100 percent increase in precipitation from work that he was doing or looking over the paleo environmental evidence.

This yielded a change in recharge of 15 times the current estimate and when he ran that through his model, he found water table changes of 130 meters through parts of the Repository and flow pass shortened to the actual environment as well as the model which would define it by two-thirds.

So, if you had a condition such as this, unsaturated zone, it would by definition from the disturbed zone to the water table, would only be 20 meters, not 200 and that together with what you'd expect an increased flux if you were to have any kind of a long time change of precipitation could yield travel times very short.

So, I think it's, incumbent upon us, whoever us is, I mean everybody could take a good look at the historic development of the regional model and go back and actually fill in some of the holes in those analysis beyond what has been proposed in the site characterization plan.

There are a number of things that are proposed to the site characterization plan and most of them relate to various specifics such as the long 40-mile swatch or the primary potential for recharge out in that area.

DR. DOMENICO:

I've got a geologic question. I have been waiting for you.

Everybody knows the strategic or the strategraphically of Yucca Mountain and I'm looking at the Calico Hills here and does anybody know how extensive the Calico

Hills might be from Yucca Mountain and let's say in a sunward direction or does anybody know the first known volcanic rock unit that exists strategically as well as defined regionally?

MR. FORDHAM:

Well, south of Yucca - -

DR. DOMENICO:

It is well defined.

MR. FORDHAM:

No, there are no holes once you get to - -

DR. DOMENICO:

We are talking about a hydrological model of something that we don't know anything about.

MR. FORDHAM:

Once you get south, there's not a whole lot of data.

DR. DOMENICO:

For all you know Calico Hills may be ambiguous only to Yucca Mountain, is that possible? I'm asking because I don't know.

MR. FORDHAM:

No, I don't know.

I am the wrong one to ask that question.

DR. DOMENICO:

But, no one knows how extensive these deposits are laterally?

MR. JOHNSON:

I think a response to that is, as you saw on one of John's slides, very limited drill hole information that we had south of Yucca Mountain and I think that that is indicative of one of the concerns that John has tried to bring out is; we don't have a lot of

drill hole information between Yucca Mountain Repository area itself unless we get to the Armagosa Valley.

DR. DOMENICO:

Which is gravel entirely?

MR. JOHNSON:

We don't have a lot of information as to how extensive some of those are or some of those volcanic units are to the south of us, so we don't know the distribution of Calico Hills to the south of us.

We have only one hole at the Repository area itself which is OP and whether or not it has even penetrated completely through the complete tuff tile and that has encountered aleous rocks which - -

DR. DOMENICO:

Which ones are carbonate?

MR. JOHNSON:

The carbonous units, but we only have one of those holes.

CHAIRMAN DEERE:

Where is that located more or less, do you know?

MR. JOHNSON:

That's just on the east side of Yucca Mountain Repository block.

MR. FORDHAM:

Somewhere there, approximately in that area.

DR. DOMENICO:

Does it seem funny to anybody that we are talking about the numerical model without moving it strategraphically?

MR. JOHNSON:

Yes.

MR. FORDHAM:

Yes.

MR. JOHNSON:

I think the answer is yes.

MR. FORDHAM:

I think we need to go back and take a good look at the overall regional system once more.

There's perhaps some more data from existing holes at the NTS that might refine that. There are new data gathering holes proposed related to the weapons program and will be monitoring the holes and a few hydrologic holes that should, I guess, be in the same time frame and we are looking at 5 to 7 years to begin to ductile and begin to provide information in areas where there's probably very little and essentially no information, no real information about what is happening north of the site of Mesa and Timber Mountains.

Nothing is proposed from that either that fluxes together with the flux boundary together with the 40-mile wash area and certainly those were the ones that were most sensitive in the models that have been done to date with respect to transporting from the Repository.

DR. DOMENICO:

The more I picked on the south, because that's the presumably, the direction the water is moving from the site and I think is of most concern.

MR. FORDHAM:

That's of most concern to people, yes.

DR. DOMENICO:

You have no idea what the first known volcanic rock is underlying Yucca Mountain?

MR. FORDHAM:

I don't think anything has penetrated.

MR. JOHNSON:

Just that one drill hole has penetrated the sorbin and carbonate rocks.

DR. DOMENICO:

That is the so-called carbonate?

MR. JOHNSON:

That's a good question.

DR. DOMENICO:

It's a carbonate rock?

MR. JOHNSON:

Yes, carbonate.

DR. CARTER:

Let me ask you a question relating to the same thing.

I presume that weapons people for many years have been interested in the movement of the water table of the saturated zone to the south again, because that's where the impact of the public domain rather than the Test Site control is, so I'm sure there's a lot of information that is available in measurements of this sort of thing.

MR. FORDHAM:

There's a lot of information in the Yucca Flat area and we see in that area general hydraulic data showing water moving down from the - -

DR. CARTER:

Do you have access to this information and I presume the ground water flow is reasonably slow, is that true or not true?

MR. FORDHAM:

As modeled?

DR. CARTER:

Well, I think it's been measured, but I don't think it's a question of modeling.It's probably been both.

I think we have or they have been measured or measurements have been made, but whether the data are available is maybe something else again and certainly there must have been a concern for many years about the movement of the ground water and the potential movement of the radionuclides off the Test Site.

MR. FORDHAM:

Yes, significant concern there.

DR. CARTER:

Is that data available? That's the question?

It's more than modeling now?

MR. FORDHAM:

Those data all should be available and some of the original modeling was based on, at least the composite heads in these areas, but there's indication that water is moving down in the Yucca Flat area to the carbonate, whereas the only evidence at the site is, there's one hole that says the grading is up from the carbonate and has been penetrated and yet you get into the area and you don't know what happens and the alluvia here is the real thing and there are no deep holes in this area, but you have discharge of Ash Meadows which is essentially or basically all from the carbonates.

You have got structural control over here.

DR. CARTER:

I guess the point I would make is that; we have had underground testing now for 20 plus years and I'm sure that ground water has been measured for most of that time if not all of that time and certainly where water is discharged and used publicly has been measured to the best of my knowledge, but now they have never found any nucleods?

MR. FORDHAM:

The radiance in that area are quite flat.

You look at these and this is what, 80-meters, I guess it is and I can't read the scale there, but 30 or 40-kilometers, so you would expect to have a fairly slow movement of water.

DR. CARTER:

Okay.

MALE VOICE:

I'd like to ask another question about hydrology, if I may.

We have a bad example of what has happened after thorough consideration and reflection and technical studies of what happened in Idaho.

Is that going to happen in Nevada?

CHAIRMAN DEERE:

We have asked that - -

MALE VOICE:

What happened in Idaho and the contamination of hundreds of square miles of - -

CHAIRMAN DEERE:

We asked this morning and at the beginning and perhaps I should have repeated it, but we are here on a fact finding mission to hear the presentations and we asked that there be no questions from the audience at this particular hearing.

We will have it opened later, at a later hearing for questions. Thank you.

MR. FORDHAM:

Dr. Carter, if I can finish up and answer a little more detailed response to your question concerning the weapons program.

On the Nevada Test Site, there's quite a bit of work done early on and in fact, on the hydrology of the Test Site.

Since that time, there's been very little emphasis placed on hydrology at the Nevada Test Site and only in the last several years with the passage of hydrology has it begun to take the front seat.

Again, a lot of holes of opportunity are on the Nevada Test Site and generally have got us or are very useful for hydraulic or hydrologic purposes and designed for other purposes.

DR. CARTER:

I appreciate that that data is not available and I'm sure they continue to make measurements in the ground water and off the Test Site and this certainly is a major interest of the movement of those nucleods be publicly assessable.

(Whereupon Scott Tyler takes the presentation podium at 2:35 P.M.)

MR. TYLER:

That information is assessable to both the DOE and the State and I would like to discuss with you, the transport model and what I call a realists view of transport modeling around the Yucca Mountain site.

As I go through my presentation, you may find that it's a rather pessimistic view and you will see that view is shared by a considerable number of people.

Why model transport, the question is rather rhetorical and obviously the system of porous unsaturated rock or Yucca Mountains or anywhere for that matter, have a very complex process. The area has not received much attention in the literature or scientific community over the last few years.

Hydrology or hydrologists were not concerned with it because you couldn't pump any water out of it and because - - hell, you couldn't put a flow through it, so it wasn't of great interest to them.

So, we are caught in a quandary. There has been very little work done on this rather complex process, so we are trying to come up to speed and ramp up quickly.

Obviously, we have to model a very complex set of processes. We have regulatory requirements, estimates of travel times and concentration for 10,000 years and perhaps even longer than anything we have tried to assimilate in the past. Models can give us some idea of uncertainties in our estimation and we can get uncertainty analysis out of it and also use our conceptual models to improve data collection techniques and in looking to see where the model is most sensitive and where it gives us the highest sensitivity and try to sample in those areas.

We can use models in experimental procedures so we can design experts better than optimists or optimistic data collection better temporarily and spatially.

What is in a model? It's a conceptual approach to coupling in this case and referring to Yucca Mountain, transport of contaminants or transport of fluids, being gas or liquid and huge transport, conduction and convection with a medium composed of and highly variable and also chemical properties and also probably a few other things too.

Also under the influences, I have listed a few forces here. We all know gravity surface forces representing capillary adherence forces of water and interfacial forces, buoyancy forces, thermal forces that tend to drive the buoyancy problem and we may be aware of the tectonic forces or something that hydrologists aren't overly used to dealing in and osmotic forces and that is, differences in chemical potentials between fluids and probably quite a few others which science has yet to determine.

The question is; that the model is not simply a computer program. A computer program is simply a methodology to solve equations or merely a tool, but not the end all.

The processes that we are being called on to model on the unsaturated zone in Yucca Mountain, both by the Department of Energy and its consultants and contractors

and also the State is; liquid flow in both porous and the fractured media and that is a media comprised of small porous which by stepping back a little bit, look fairly uniform and then a fractured media which contains large joints of these two are coupled.

They are a coupling between the porous and fractured phase.

We also have chemical transport. We have an advection, a term that some of the species are carried along with the fluid flow, either liquid or gas.

We have diffusion process which we probably have a good handle on that and absorption which is a good question, absorption of contaminants on metamorphous and your radio active decay, which I think we know that pretty well.

In the gas phase with the diffusion processes and advection, meaning that it's carried along due to pressure variances, either we have convection due to thermal point affects and we tie on that heat transport, admittedly, at the present time the thermal grading is probably not particularly steep and may not affect the flow of these three phases, particularly significantly, but upon loading of the Repository with 70,000 metro tons of hot spent fuel heat transport, may be the dominant process.

We then have a conduction of heat, both in liquid gas and solid phase and we have a confection probably in gas phase, but to some degree in the liquid phase.

Another process that is critical is the rock mechanics and that is interplayed between stress and strain effects on hydrological properties or hydrofracturing and that is the opening of fractures to release stress within the rock material.

All of these five processes are highly coupled in that, that is a small change in one of these processes has significant effects and each one of these processes which in turn turns back and affects the original process in a highly non-linear fashion and incredibly complex problem or if we try to assimilate all of these at once, a process has not been done to date, by the way.

Now, the Department of Energy and the SSCP forms as a look at fluid flow

and transport using carcia (pho.) flow with despoliation in fractured porous media, which is a process that will be used as a base line case to describe further movement from an unsaturated and saturated hydrologic units.

This is a traditional approach to ground water contaminant transport and again, back in the early '60's.

Let's look at some base line understanding that we have of that process both uncertainties and the fluid flow or uncertainties in the transport process.

I'm going to ignore the other processes for now. What I want to show you is what has been recently published in the literature with regard to flow and fluid transport and uncertainties therein.

To give you a flavor of where I think the state of the art currently is or where I think it can go by the next 7 or 10 years during the Repository licensing time, we have Evans and Nicholson currently under contract with the Nuclear Regulatory Commission to look at the unsaturated flow in Arizona, said, "The ability to characterize and model media composed of both matrix and a fracture component is in the development stage."

That was in 1987, two years ago and they are still in the development stage. These are people currently working in fracture.

Next, we have Witherspoon and Long, in 1987 said, "A major problem that must be faced is that of determining the location of all fractures and describing their properties.

We can at most, hope to describe the fractures and derive the properties of the network in a stochastic sense."

There's a correlation in the properties and we need to understand that correlation structure that says that you need a lot of data.

Continuing on with uncertainties in liquid flow and ignoring the unsaturated

flow, but this applies to the saturated and unsaturated fracture flow.

This is from Tsang, 1987 they have a model of channeling in fractures and have said, "Field experiments called attention to the fact that the parallel plate assumption of a single fracture may be incorrect in describing the fluid moving through it."

The alternate model which is not based on field data, but then we have Rasmussen and Neretineks, in their research of water resources in '86 said, "The theoretical analysis has clearly shown that, in general, that channel geometry and the frequency of channels have a very strong impact on the transport of dissolved species. Such data are largely not available."

So, we need to describe in detail the hydrologic connection of practice, be they saturated and unsaturated, but some method which affects the hydrology or hydrologic properties and that requirement or requires a collection of data and we have Anderson and Dverstorp said, "One of the more important directions of future resources is to explore the validity of the model assumptions and preferentially substitute them with more realistic ones."

One of the most important directions is to explore the validity of a model and assuming that that is the test or the current model, we have again actual field data and we need to substantiate them with more realistic information.

Remember that the data is one of the 1969 and have proven to be ineffective in model fluid flow and transport in hydrogenous media.

On the other hand, we have Nielsen, van Genuchten and Biggar, soil physicians who say, "A major message of this paper is our belief that present work and flow and transport lacks a unified approach that includes all pertinent, physical, chemical and biological processes operative in the unsaturated soil."

These people are talking about soil zones and this is our basic understanding of soil or soluble transporting of soil.

Now we move on to transport. We did liquid flow and now we will do contaminant transport which is of my interest and transporting, being the movement of chemicals species either the liquid or gas phases and understanding the dispersement therefore.

The last decade has seen rapid developments in theoretical research treating ground water flow in a probabilistic framework, but actually field application has been very limited.

"New theoretical approaches will also be required to treat the extreme heterogeneity of some natural permeable media."

Gelhar has developed early work on the statistic theories in ground water transport or what is an extreme porous media interspersed with fractures of the rock matrix and new theoretical developments will be needed there.

Moltyaner and Killey have done a recent paper in water resource or resource conclusions show in that, the estimated dispersivity value is significantly affected by sampling procedures, sampling frequency and monitoring network in that the classical advective dispersion equation adequate representation of column and field scale experimental data."

"The stochtic convention-dispersion model has not yet proved useful in shedding fundamental light on the scale effect of dispersion-the assumption of homogeneity and ergodicity in the random hydraulic conductivity function need more experimental verification."

The dispersivisity value is significantly affected by sampling procedure or sampling frequency in monitoring network design and in this case, the classical advection dispersion equation provides adequate representation of columns of field samples based on sophisticated example sampling approach which matches the scale of experiments with the scale of observations.

We don't see that in the SCP.

The assumption of homogeneity and ergodicity of a uniformness or ununiformness which I will tell you later about that is a long story, but the random hydraulic conductivity function is what is driving the transport and we have to define the hydraulic conductivity on space and time.

We need more experimental verification.

Getting into the aspect of spatial distribution or distributions in the two examples mentioned leads to the conclusion that it is extremely difficult, if not impossible, to predict accurately the point value of concentrations.

That's common sense and although we'll not be able to predict exactly what's going to happen on the fractured rock in Yucca Mountain. So, where does this lead us, where are we going?

The current directions in flow and transport research are toward stochastic or probabilistic methods. The stochastic methods require a detailed understanding of hydraulic property variation within the simulated region.

Particular emphasis is on spatial correlation of properties. This is critical and still hasn't been tested yet. It's still in their infancy in saying that we need to collect a lot of data and so we can't understand the spatial property and they have not been significantly tested due to lack of field experiments.

I can continue on with the fact that there are a number of saturated zone control transported experiments and probably I can count them on two fingers, the amount of unsaturated zone controlled experiments that have been conducted.

Now, the DOE and its contractors have proposed the following things to characterize the unsaturated zones and the saturated zones for that matter and the transport flow of contaminants at Yucca Mountain.

We have got 11 deep bore holes in the Repository block of unsaturated zone

data, plus and minus and as I read the SCP and probably there's something hidden there or I added some that I saw twice that show those who know it better and can probably come up with a slightly better number.

Eleven deep hole or deep bore holes in the unsaturated and we have an understanding of the hydraulic properties of 16 bore holes for the saturated zone for detailed hydraulic property data.

We have got 3 unsaturated bore holes in the Calico Hills units beneath the Repository block which is prime travel time if you will beneath Yucca Mountain.

There are 3 bore holes to assess hydrologic variations. It's hard to straight line with 3 points because the third always outlines, so you should have 2 or 4.

We have one or two multi well field tracer equipment, 100 meter scale at least in the saturated zone to assess transport in and there's a possibility of a second meter scale to provide the first one as working or doesn't work and provides interesting information.

The five tests that are being worked on on this project both in this State and the Department of Energy, they are my friends and colleagues and they are good scientists. I'm not trying to out anybody down in this, however, they are being asked to do something technology is not available to do and been asked to do something International for time frames and it would be very difficult for them to achieve the goals of characterizing, I believe anyway, the unsaturated zone or saturated zone at Yucca Mountain.

What one can be best hoped to do is, I think, with this kind of data collection system, would be to characterize the process understanding in the greater detail and the process of that is transport and fractured rock, but I seriously do not believe we will be able to characterize the site of Yucca Mountain and we'll get a handle on the process and have an awful hard time, I think, transporting to actual field site saying that this is what is going to happen.

With that, I'll be happy to take any questions.

DR. DOMENICO:

How are you using ground water? How are you using that concept?

MR. TYLER:

I'm using it in the context of what was recorded in '86, either the first arrival or based strictly on - -

DR. DOMENICO:

Well, why, my understanding is that you may be giving the panel the problem which is complicated, but the problem may not be as complicated as you presented it, because first of all, it's placed or pre-placement ground water travel time and second of all, no thermal effects to be considered at least in terms of ground water travel time and third of all, the release vented by the EPA is mass release, not a concentration, nothing in regulations right now, say that you have to predict concentrations on a 10,000 year period so it's still an immense task, but there's likely that the DOE as you stipulated their data needs, in other words, they need to get some idea of what is travel back to the front and also the other stuff, to get the data on the velocity of eviction itself and you need to know a few things on retardation and you have a travel time calculation.

It's still a terrible job, but I'm not quite sure it's - - you require the data and the thermal affects and all the other affects that you alluded to to approach for survival time and you may need it for other lessons and that's why I asked how do you mean ground work travel time?

MR. TYLER:

I'm not tying myself down to that, the specifics, but more concerns with the overall performance and the performance assessment was what I was trying to tie into with what would be the release rates and transport properties of this material, that is the fluid will be flowing through not specifically tying onto one number, that's a ground water travel

time and we have to understand a hell of a lot more than travel time.

DR. DOMENICO:

I agree, but in order to have a licensable Repository, one can be licensable, you have to meet certain mass release and one percent is concentration which makes the problem one hell of a lot easier, not easy but easier.

MR. TYLER:

I'll grant you, it's not easy.

DR. DOMENICO:

Not easy, easier.

MR. TYLER:

You can throw away a lot of my ideas of transport and there's quite a few overheads that uncertainties as well, but also I'm not convinced that we can ignore thermal affects, at least in the unsaturated zones.

I'm not 100 percent sure on that or it may have to include these here.

DR. DOMENICO:

On the release criteria you can, but for release, other reasons you can't.

DR. CARTER:

I had a comment on the question.

We enjoyed your unbiased and balanced review of the literature and the question is; you have a relationship or do you have a relationship at all with any of these international modeling efforts that are going on?

MR. TYLER:

We are some degree.

Linda Lehman is.

DR. CARTER:

It's a Swedish International environment transport that we are - -

MR. TYLER:

We are in a validation exercise, an International validation exercise and we are getting more and more involved, so yes and no, but we need to do more of it.

DR. WILLIAMS:

I'd like to make a comment about your approach that might be confusing.

I have learned that there is a great deal of confusion about the application of the scholastic processes to characterize ground work travel time and there is no such thing as a way of measuring properties of rocks, scholastic and there are no scholastic tests procedures that are simply a way of treating data derived or eluded to the fact that you could do the other, but you can't do that.

MR. TYLER:

Well, a lot of times we could take field data in in order to - -

DR. WILLIAMS:

You take field data by some other method or you might arrange your programs so that it can be analyzed scholastically, but you can't determine hydraulic activity by scholastic procedure.

MR. TYLER:

No. If I said that, that was not my intention. We can use the present probabilistic methods to get a better handle on the interpolation, so that we are estimating parameters and include the spatial correlation of whatever the property happens to be to improve our estimation, but it's still an estimation and not a measure of property.

DR. WILLIAMS:

I might point out that the NRC Technical Documents in that regard.

MR. TYLER:

Thank you.

CHAIRMAN DEERE:

Thank you.

(Whereupon Linda Lehman takes the presentation podium at 3:00 P.M.)

MS. LEHMAN:

Good afternoon, Mr. Chairman and Board members and consultants. My name is Linda Lehman and I'm here to talk to you about the uncertainty in modeling and performance assessment similar to what Scott Tyler and I hope I'll cover a little bit more ground.

Basically, I'm going to start out discussing sources of uncertainty and then spend quite a bit of time talking about data limitation with respect to performance modeling and point out some recommendations.

Cranwell and Helton in 1981 suggests that process modeling input data and scenario uncertainties and the primary components in uncertainty.

Our knowledge of unsaturated flow and fractured rock as Scott Tyler mentioned, is basically what we have learned through the science of soil physics, that which is dealt with the first two or three meters of soil.

We virtually know nothing of flow and transport and fracture rock at the scale of Yucca Mountain.

With respect to scenario uncertainty and certainty is one thing I might say is that scenarios are very, very uncertain and basically what we know about frequencies of occurrence is just a guess and in most of the processes we know less than what's going to be the effect of those scenarios, especially like tectonics on the hydrogeologic system.

Now, Eisenburg, in 1987, identified five broad classes of uncertainty.

1. Systematic and random error in measurement.
2. Spatial variations in geologic parameters.

3. Conceptual models.

4. Physicochemical process modeling.

5. Future states of nature.

With respect to future states of nature, I would like to say that the ability of a model to explain a phoenomenum is only weakly correlated to its ability to make a good prediction.

The model is fundamentally sound or if it's not, the parameters and barriers could be adjusted to explain.

In other words, we do not have a big solution, so there's really no reason to expect the predictions based on these types of models will be accurate, especially over a 10,000 time or 10,000 year time period.

The Nuclear Regulatory Commission has also identified data uncertainties, data limitations of a source of uncertainties in formulating conceptual hydrologic models and insufficient site characterization as a source of uncertainty in estimating ground water transport times.

Now, when we were developing performance assessment models in tuff or in any other medium, we need to look at the water conducting element in tuff and fractures or other void spaces within the rock and matrix pores.

Several other presenters mentioned the large degree of heterogeneity that we have and therefore, since we do have large variations, it's necessary for us to use average models when we are modeling.

The formulation of these average values are crucial importance, not only to describe the rock, but also to be able to interpret measurements and experiments that will be ongoing in the field.

Ten CFR Part 60 requires us to have thorough knowledge of flow field and also be able to model some of the mechanisms important to transport and I have listed or

Scott Tyler listed a few others that are important that basically are advection, dispersion, absorption, matrix diffusion, chain decay and colloids which are the main mechanism.

The question is not so much if they occur, but to what extent do they occur.

Again, heterogeneity becomes important in order to describe these processes or mechanisms and we must set up a spatial structure in determining the spatial structure which adds additional uncertainty to the process.

The most commonly used spatial structures are homogeneous porous medium, with or without fracture zones and Scott mentioned this first mechanism, this homogeneous porous medium approach possibility with fracture zones is the preferred approach that the Department of Energy will be taking and this is a simplistic approach even though this is very difficult to use with any certainty in the results, but still requires a less amount of data and essentially the medium is characterized by hydrologic conductivity of the rock matrix in the first point and when you're dealing with fracture zones, you must consider hydrologic conductivity of the fracture zones and you need some sort of way of averaging to come up with an overall average which as the account of permanentability of fracture zones as well.

Heterogeneious porous medium is the next one and basically that involves using a statistical frame work in conductivity field described by a single covarious function.

Destroying fracture networks, these are characterized fracture orientation and the problem as Scott mentioned, also that they are very, very difficult to estimate model parameters from experts but fracture property may be a function of space and they are extremely or extreme data insensitive with respect to channel network and fractural geometry looks promising only in the early stages of development with respect to channeling.

What we mean by channeling is that the water does not fill the entire

fracture, whether this is a planned view of the surface and there are open places within the fracture and enclosed spaces and the water would move only through the open spaces and obviously there are different ways of channeling.

You could have a very distributed system of channel and very intersected or in the extreme, you could have what we call an extreme channeling which only is of these channels actually transports most of the water and this is an important thing for us to find out at Yucca Mountain because of the implications that channeling has on the other retardation mechanism and the matrix diffusion, obviously, if most of the water is moving through a small channel, you have less surface area available for absorption and other mechanisms to take place, so with respect to performance assessment, some of the most critical questions we have with regard to what I call barrier functions or how well this system of radionuclides is on the retard.

First of all, what is a proper description of the spatial variability of the rock, is it a system of poorly connected fast channels or not?

Secondly, how much capacity of absorption in matrix diffusion or generally available?

Are colloids an important transport mechanism?

Will the coupling between ground water flow, rock stress and rock deformation seriously affect the long term function of the Repository?

I think as we go through our data collection efforts, we need to keep these critical questions in mind.

Now, with respect to data limitation, first I'd like to talk about general limitations to data and secondly what I call data limitations to do with insufficient site characterization.

Most of us are familiar with general data limitations and hydrologic parameters and as we discussed the flux cannot be measured directly in the field. It has to

be calculated through measurements of hydrologic radiation and conductivity.

Many hydrogeologic parameters are obtained from inference.

Many parameters are assume correlated to other parameters.

Representativeness of samples collected.

Number of samples.

Sample disturbance during sampling.

Measurement and interpretation error.

There are a number of sampling questions and a number of samples usually have to do more with cost. Now, I'd like to talk about what I call the time dependent limitation and that is the time of site characterization or time allocated for data acquisition to acquire the data needed for a licensable application and this limitation fortunately is correctable.

The time line of the Department of Energy has allowed for site characterization which can be shown on this slide and this was handed out at the Advisory Committee or the Nuclear Waste Committee I believe in January or February of this year.

They show here the start of the shaft construction at about this time, 1989 the middle of the year starting inside with two testings in the fourth quarter of 1980 and that leads to approximately this point when the license application is due or 4 years from now.

We have heard that since that time, the shaft has been delayed until November of this year and recent articles in the Nuclear Waste News indicate that it may not get done that soon, so therefore, instead of 4 years for inside to testing, we have maybe 3 1/2 or less to get all the data that we need to go into a license application.

At that same meeting, a DOE manager described the performance assessments milestones and the data that would be used to develop the performance assessment to go into safety analysis report which is the license application.

As you can see here, they begun the actual testing in 1980, but the only bullet that we see are interim based test results and that these are the only data that are going to be used in the performance assessment for the licensing application, you will notice nowhere on here is there anything about inside two at department data being used in that performance assessment.

That was particularly disturbing to me because when I was at the Nuclear Regulatory Commission, when I specifically asked the question; do we need to go underground inside two facility before we can confidently issue a construction authorization and at that time, the answer was yes, and therefore, we have gone ahead with an underground facility, hoping to have data which to base our judgment on.

To my knowledge, the NRC has not changed that or their mind on that point or it doesn't appear that the DOE will be using any inside two data other than confirmatory, since from as far as the surface base data and I think we need to ask the question of, at what point does the schedule inside two testing scheduling from ambitious to unrealistic.

I submit to you right now the schedule is unrealistic and in order for you to determine that, I think we need to ask three questions.

First, what data will actually be used in the license application and what will be it's quality and how long does it take to generate data?

To give you an idea of this last question, I put together two tables. These tables are the hydrologic data that we have received from the Department of Energy for the saturated and unsaturated zones basically in the saturated zones, we have two types of data.

We have water level data and we have draw down and recovery data from pump tests.

Period of time which the water level data and there are two times, but the inside two pressure transducer data and the data taken by steel tape hand-held

measurements.

The pressure transducer data collected in '83 and '89 and we also have data from the U.S.G.S. in March of '87.

The data that we are in very bad shape over and we would ask them to redo some of the data and give it to us back in a Q-A'd form and however, we still have not received that.

If you want to say that the time of turn around from a non Q A'd data is anywhere from 4 years to 1 year.

This hand held data were taken from 1981 to 1987 and that data we'll publish in the 1989 issue so essential 2 years to 8 years it took for us to receive the data.

DR. CARTER:

How do you get fair data out of that measuring of something with a yardstick essentially and I'm just curious?

MS. LEHMAN:

Are you talking about this number?

DR. CARTER:

How do you, how could you screw it up that badly?

MS. LEHMAN:

There are a lot of problems with that, that particular quality was mine, but it's the same from the information placed on the U.S.G.S. publication and the problems that they had changed methods and times and types of tapes and tables and when you look at the record, when they have made a measurement like that with equipment, you have a change drastically.

DR. CARTER:

The equipment is not calibrated?

MS. LEHMAN:

Well, that's a problem with the - - I wasn't prepared to get into all of the problems with it, but if you'd like, I can.

There was a number of problems with the water level transducer data from supplying errors to calibration.

DR. CARTER:

I think a few minute diversion on that would be interesting, because those are harsh accusations about data collected by reputable agencies.

MS. LEHMAN:

Okay.

With respect to what I call "poor" on this first one, we came upon that designation when we tried to analyze the data and basically what I wanted to look at was the change of water level over time and I was trying to do a time series analysis and you go for a year transform in order to do that.

We started and we had to change the pressure transducer data given to us in intervals to water levels and when we started looking at that, we discovered that there was a factor called a submergence factor calculated periodically over time.

This submergence factor is calibration method where they raise and lower the transducer up and down a foot and take a reading so they are sure how much change in mile volts equals one foot.

When we started looking at that, some of the wells, the submergence factors had to be calculated ones and some of the wells may have been calculated five times and some only twice or three times and in several of the holes, it was calculated twice the same day and on those dates that it was calculated, twice in error was determined and we'd have one reading way up here and another reading way down here.

So, one of my thoughts that I can recall had 5 data points, two on the same day widely spaced, one in the middle and two on the other and I thought, well, what do I

use?

Do I use the lower figure or the average because it resulted in about a 7 percent to 10 percent was the best percentages that I could get of error which was 7 percent, so I thought well, I can use this defensively. I can't change it.

And the data were initially taken to be used for water levels and that's why I'm saying the quality is poor.

The data can be used for other things and you can take frequency analysis on the reading so that's what we had to do and that's why I have the designation as poor.

When we received the data, it was not spliced together correctly and we had gone along reading a WT-1 and all of a sudden it would be WT-3 or WT-6 and we had not idea which was which and we asked them to take it back and get it straight and we have not received that yet.

Back to my initial train of thought here; the draw down and recovery data we have received that in 1987, but the tests occurred from 1980 to 1984, so anywhere from 7 to 3 or to 7 years to turn around that data.

In the unsaturated zones things are much worse. We basically have not gotten any data even though the UC-1 was instrumental and tested in '83 and '89 and the laboratory work was done from '83 to '85 and preliminarily the results on this lab data were presented in a, I believe it was a National Water Well Association meeting in Denver several years ago, but none of it has ever been presented to us in Q A'd or for that matter, never have seen any raw data.

And this data has been termed, "Suspect," by a letter from the U.S.G.S. They feel that this data may not be released because of the quality of it.

So, that's why I had it suspect as per U.S.G.S.

Basically, as you can see, we have essentially no data to base the opinion that unsaturated zone of Yucca Mountain is a good place to put a Repository and although,

major conclusions are historically reliable, good quality data are not available for at least 2 years after a test is completed and I say that that's a conservative estimate and you saw the numbers here and 2 years is generous, I think.

DR. CANTLON:

If the State of Nevada were conducting its own parallel study, would you estimate that it would require 2 years from field to set of usable data?

MS. LEHMAN:

No, I don't believe it would. I think within the State of Nevada, once they collected the data, it would be turned over immediately to the contractors that want to do it.

Some of the reasons it's taking so long is, you know, the U.S.G.S. has long internal review process and on top of that, we have a lengthy Department of Energy review and basically what this means is; if we have a 4-year period for site characterization, which we don't, but if we did any tests, that last listed longer than 2 years, it would take 2 years to get the data and that data would not be available for the licensing application and a number of tests that are planned in the site characterization plan are prototype tests and these typically do not function perfectly the first time.

You're always going to have to redo them and some of the examples which Dr. Carter mentioned earlier, a lot of it, I'll say all of the unsaturated zone experiments had to be done over again and because they didn't collect it correctly the first time or the boundary conditions weren't exact or something.

Essentially what we have is, is a licensing application that's going to be based largely on sparse surface based testing without any insight into data.

Now, the recommendations, in order to ensure a high quality and complete license application, the NRC and the DOE should move immediately to correct this time limit differential and first determine immediately how much inside two data will be

required in the license application and it's quality and then the deadlines need to be extended to allow these data to be reliable or reliably collected and interpreted and we must stop compromising this schedule.

Whenever we have a delay, we comprise the schedule and we don't extend it on the other end and the deadline must be moved commensurate with the delays.

Additional representation, we need to expend our research into basic processes and these are processes needed to address the critical questions which I mentioned earlier and those research needs are in unsaturated flow and fracture porous media and we need to log studies, not the type you generally hear about through the DOE and they call us and allocate some of those and logging programs which are looking at the chemistry and transport, but those are not the types of studies I'm referring to.

What I'd like to see are some studies and basic unsaturated zone flow and there are two places that come to mind.

One is near Mesa on the Nevada Test Site, the northeast corner of the Test Site and Scott Tyler under the Weapons Program did some calculations of the flux through the Mesa area and found velocities were extremely rampid and you could get immediate water down in tunnels within a year or two years; is that correct?

MR. TYLER:

Possibly.

MS. LEHMAN:

Also, in Arizona, there's a place called Apache Ridge Tuff site being sponsored by the or a mine located some 3 or 4 feet through the Queen Creek which flows on top of this and whenever the Queen Creek floods, they see within two days increased flows into this mine, so this tells us, you know, our basic Richards equation formulation of flow may be completely wrong for unsaturated zones at this scale.

Also, I don't want to sound like a broken record, but coupling of the tectonic

process and other processes needs to be studied, so in summary, performance attempts and modeling uncertainties are extremely large data limitations are severe, but some are critical and even with good data, we'll not be able to rely on models and predict the unsaturated zone.

Scheduling compression must stop and quality of license application is at risk and the deadlines must be moved to commensurate with delays if this not done, then the license application would be based on sparse low-quality surface based data and I'll be happy to answer any questions.

DR. CARTER:

You're not being completely fair now about the schedules.

I think both ends to the middle of the schedules have slipped and many times - -

MS. LEHMAN:

No, the other end hasn't slipped, I don't see.

DR. CARTER:

Not ever?

MS. LEHMAN:

Did it slip at all?

MR. LOUX:

'95 has been the deadline for the submission of a license application for 2 or 3 years.

DR. CARTER:

Earlier there might have been changes, and I think that probably obviously, if you press the front end of it, evidently something has got to give and I certainly agree with your representations which are purely reasonable and it should slide both and not just with one.

MS. LEHMAN:

I think we need to or otherwise we are sacrificing this science.

DR. CORDING:

One question on the comment or a comment rather and that is the Mesa travel times.

Several areas such as the Rainier Mesa have undergone quite a bit of shaving and tapping on the nuclear weapons effects.

Can you separate that out or do you have information regarding Mesa that you think basically is undisturbed?

MR. TYLER:

The data suggested rapid transport time recent in accuracy and other data involved with the testing program, but it's obviously disturbed type of rock and on the other hand, it has potential through some analogy to basic studies.

DR. CORDING:

I certainly think it's worth looking at.

MR. TYLER:

Those estimates are based on thinking and it's not a natural system anymore.

MS. LEHMAN:

This is a cross-section which I brought in case there were any questions.

DR. CARTER:

Linda, how do you interpret colloids. You mentioned that, but you didn't mention if it is plus or minus?

MS. LEHMAN:

I think there's certain potential colloids.

DR. CARTER:

I think that might be desirable.

MS. LEHMAN:

If you have extreme channeling, it might not be.

DR. CARTER:

So, it's neutral at the time?

MS. LEHMAN:

I don't know. The important question is; to what extent is it operative.

CHAIRMAN DEERE:

I think we'll take a 15 minute break now.

(Whereupon there was a recess taken in the proceedings at 3:30 P.M.)

(Whereupon Maurice Morgenstein takes the presentation podium at 3:45 P.M.)

MR. MORGENSTEIN:

I'm Maury Morgenstein and we are going to talk about retardation and retardation credit.

Retardation is credit is needed for radionuclides that require isolation in the host rock in order for the Repository to meet regulatory criteria.

These radionuclides that require isolation are considered Key Radionuclides.

Isolation can be accomplished by sorption, precipitation, ion exclusion and diffusion mechanisms.

The radionuclides that we are most interested in at this point in time are the Actinides and the first two groups are most probably going to be transferred by ground water and carbon and that's Carbon - 14 and mostly by vapor gas emission or emissions.

This dialog can be summarized as follows. We need suitable minerals

available in the path of travel and there will be zeolites, clays, fe & Mn oxyhydroxides.

These minerals should be stable in the ambient temperatures. We would like to see low sodium water concentration and high silica activity, especially for the minerals that have to be accessible to transporting fluids.

In other words, it's not just important that we have 25 percent or 80 percent clinoptilolite, which is a sealant in a particular horizon or we have to know how much of that could be made accessible fluids and this can be a function of the orientation of crystals of the zeolites and can be a function of whether or not the zeolites would be covered by other artigenic minerals which are absorbers.

Possibly, in a fracture system, we might see fractures completely coated with clinoptiolite are also coated with opal, therefore, the clinoptiolite wouldn't have accessibility to the transporting fluids.

Other factors affecting retardation barriers and that's mass action competition. Each mineral has it's own selective wish list for various fluids and favors one over the other.

The formation of the multiple specifications, dominant fracture flow radionuclides which are not or are non-sorbing radionuclides and possibly soil gas circulation.

We have mentioned previous problems with soil gas circulation where we possibly have an interconnection from possibly the Repository horizon with the surface through breathing fracture systems.

The Carbon - 14 produced at the canisters could virtually escape this in this room and may prove to be the fastest path of travel. It is a common concern.

If we are to take absorption credit, most likely that path of travel must be geochemically stable and composed of actively sorbing minerals and must be a fairly slow path of travel.

If the most likely path of travel is fracture flow, then we expect no sorption or have very little sorption because we don't anticipate enough quantity.

Absorbing minerals in the fracture system to provide any meanful retardation.

But these surfaces are coated or partially coated, we have a very selective small surface area in comparison possibly to the quantity of radionuclides escaping, however, if we have fractural flow transport which is probably rapid and sorption credit is really needed, but of we have matrix flow and this is sort of a homogeneous flow, we accept the absorption for the non-nuclides and we expect very slow travel time and we expect a lot of exposure of liquid leaving the Repository to sorption of minerals.

However, if we have a very, very slow travel time potentially we don't need sorption or retardation credit.

A third variety might be a selective matrix transport where instead of thinking a flow in a homogeneous media, we have selected transport in a matrix channeling affect and it might be as a consequence of the Repository, have very small fractures.

Here, we expect limited absorption based on the area available to the minerals to be exposed to the liquid leaving the Repository and based on the quantity of absorbing minerals that might be present in that particular area.

In this case, absorption credit would be wanted and this is probably the case where we need to concentrate our efforts with respect to studies and retardation.

DR. LANGMUIR:

I was going to object to your first comment on absorption because there are not absorbing minerals as far as I know, any absorbing minerals lead to - - it's not either or.

MR. MORGENSTEIN:

But what we should say is; limited absorption as opposed to no absorption.

DR. LANGMUIR:

In fact, it's our understanding that the iron and magnesium oxyhydroxides would preferentially be found in the fractures and they may be more significant as sorption appears and the zeolites and the real question is how much of that material is presently in the fractures, even if they could take everything, they could take, would that be significant or would it even just be our feeling that it might be nothing more than in the interest of retardation, fairly insignificant.

Further, when we think about the ion or the iron and magnesium and oxyhydroxides, we are worried about their colloids or colloid formation especially if we have ion alteration at the canisters themselves and in other words, the engineered barrier may produce more iron in the system in colloid formation than is there naturally now and although we might find some form of precipitation which would be retardation, we also might find colloid transport.

This might also apply to aluminum.

DR. LANGMUIR:

But, your canister is going to be at a high temperature where colloids are less stable?

MR. MORGENSTEIN:

That's correct, but at this point in time, we couldn't tell what might happen as we have the canister heat and bring the water in especially in light of possibly hydrogen peroxide products and nitric acid and the actinides themselves don't appear to respond to absorption as a mechanism of retardation.

And with the exception of maybe iron and magnesium hydroxides.

Although, I have no particular information concerning those particular minerals that exist at Yucca Mountain and how they would be behave. I don't know if there are any studies as yet.

DR. LANGMUIR:

There's quite a bit of data as I understand the mineralogy of fractures show presence of nuclides and oxydroxides.

The key thing would be the fluid volume versus areas exposed, I would think.

MR. MORGENSTEIN:

I would anticipate probably we'd have a variety of fracture apparatus's that we could come up with. I don't know to guess on a curve if there is a gasteon curve of fracture apertures that we could use to work it in analysis.

So, we do have concerns about the transport formation and we do have concerns about fracture flow as a mechanism which might inhibit a valuable sense of retardation and that is not to say that retardation would not exist in fractures.

We expect to see some, but not to the extent that we see retardation in a homogeneous matrix flow. Technetium, we presume will stay in solution.

We anticipate seeing absorption of the other radionuclides as long as we are dealing with matrix flow and as long as we are dealing with stable minerals.

Mineral stability is going to be a function of chemistry and Repository temperatures and as such at this point in time, we have no information on the Vadose soil chemistry, so it's difficult for me to talk to you about mineral stability or absorption or transport or in fact, most items with respect to chemistry because one half of the geochemical system at Yucca Mountain in the Vadose Zone is missing.

We have no information on the Vadose Zone chemistry so it's very difficult to make reasonable predictions and therefore, a very important recommendation is that the program must concentrate and go definitely out of its way to correct Vadose.

This is one publication where we are not sure of the value of that information and we would have to see other data to be able to interpret that.

Finally, we are very concerned about the production and potential transport of Carbon - 14. We don't have any mechanism for retardation to identify and that's not to say that one does not exist, but we have not been able to come up with a mechanism for retardation.

I will entertain questions if there are none, I will turn this over to Don Shettel for the other half of the presentation.

DR. DOMENICO:

On a report that I have seen from Abe Laremy or Abe Lareman suggested that there are other nuclides subject to vapor transport and including the TC-99 Carbon - 14 and I think he mentioned one simply because they are important pressures at high temperatures that are higher than the vapor pressure of all the other radionuclide components and he has listed 5 or 6 that potentially escape as vapor.

MR. MORGENSTEIN:

We have looked into those and we were at one point in time very worried about them and we at that point or at this point in time, we would concentrate on Carbon-14, which appears to be more numerous in its production.

DR. DOMENICO:

The point is in inventory of the large Carbon-14 is smaller.

MR. MORGENSTEIN:

Anything further?

(Whereupon Donald Shettel takes the presentation podium at 4:00 P.M.)

MR. SHETTEL:

I'm Don Shettel and the title of this talk is or is related to Geochemical Concerns of or Regarding the Disturbed Zone at the Proposed Nuclear Waste Repository.

A definition of the disturbed zone is;

"The portion of the controlled area, the physical or controlled properties of which have changed as a result of underground facility construction or as a result of heat generated by the emplaced radioactive waste such as the resultant change of properties may have a significant effect on the performance of the geologic Repository."

The NRC contributes this to mean this is an important process in permanentability application and this may be considered a factor concerning us and the last sentence there which says, "Until this time change in the state of nuclide phased having ignored an associated effects to that."

Some of our major concerns related to that observed zone and mass transport dissolution of precipitation in a thermalgradient change and Vadose water chemistry can be significant on reaching way form.

The local saturation surrounding the dried out zone than the Repository level may produce water bodies above the Repository and saturated fractures surrounding the Repository and lastly, thermal fractures which may result from boiling of water and perhaps fracture.

The massively cemented zone that may form above the Repository and you have seen this particular graph several times today, so I won't spend a lot of time on it, but one thing that hasn't been mentioned is the water table on Calico Hills towards the eastern portion of the Repository.

This rises within the Calico Hills and it widens the whole package of rocks that dip to the east in the Calico Hills thins to some extent towards the east as the water table rises.

I want to spend some time talking about an experimental or experimental assimilation of mass transport.

One reason that we have gone to an experimental simulation is to combine the geochemical models with heat and fluid phased modeling which is very complicated process and to date has not yet been done satisfactorily and these experiments are being carried out by Professor Remsted at the Cal-Poly Institute.

We have a heater on the bottom which simulates the thermal effects of the waste canisters and there was a cooling system on the top to generate the mixture.

We have another thermal grading across the system here and if the system is filled with tuffs and partially saturated with enough water and it's vented to make sure that we have maintained atmospheric pressure, although the vent may contain a trap as well as return any escaped water from the system, but what we end up with is a heat type effect and we have a counter current vapor in the powers of rock concentration of fluid phase and the great feed return.

What we developed is a stem bubble in the bottom towards what would be the Repository and canisters and above this zone we have a boil zone where you develop massive cementation of the tuffs and above here where we get concentrations of fluids, we get various degrees of leaching as the water vapor condenses and essentially it's distilled water that condenses with some COT - - CO2 dissolved in it.

DR. CANTLON:

Is a natural flow or rock or water?

MR. SHETTEL:

In the future, we intend to use fractures and unfractured activity providing we can get samples of these.

In terms of mineralogy that develops as a result of alteration, we get zeolites and abundance increases here towards the wider part and towards the zone of boiling to

make sure that we get the iron oxyhydroxides that come out of the system dissolve and precipitate and as a result of the cementation which is as a result of the opal line silica and that reach from the tuffs and that tends to precipitate in the zone of boiling.

One concern I have not mentioned is with the Topopah Springs. We have a quantity of dissolution and is not stable with respect to quarts and the transportation formalities may be excellent by refluxing the Vadose fluids away or above the Repository.

DR. LANGMUIR:

Isn't the cementation a plus in terms of isolating the system?

What is your view of that?

MR. SHETTEL:

The result of the cementation is a formation of a water body which may be extensively formed over the Repository and later on, as this rock cools down, this zone of cementation may fracture as a result of the cooling and then all the water in the saturated zone of water forms above this may rush through the Repository and trickle through.

We are not sure how that water would interact with the Repository if the zone or the - -

DR. LANGMUIR:

Can the Remsted experiments do that?

MR. SHETTEL:

Can he test that, the theory of ours on that issue or probably not, because the scale experiment is 4 inches across here by 24 inches, so we are not dealing with a very large system and it's hard to say, but we may try to simulate that, but it may be a difficult thing to do and the main purpose of this experiment is just to demonstrate the mass transport that occurs in the thermal gradient or something that is not predictable by any kind of a model that we are aware of.

Intuitively, it makes sense, but the models are not to the stage where you

could predict that.

DR. LANGMUIR:

Has anybody within the DOE program done work like this that you're aware of?

MR. SHETTEL:

There's some mention in the SAP that they are going to look into it as far as we know, but nothing has been done to date.

Our secondary major concern or all of these concerns relate to thermal pools from the canisters which are the changes in the Vadose water cone as Maury mentioned and we don't have a good handle on the Vadose water chemistry, but modeling has been done for us by Dr. Reed at the University of Oregon.

This is simulated boiling Vadose water using, I think the Mesa rather than Mesa or water from one of those wells, what we get is the PH that starts to go up or starts to within 9 and then small amounts of boiling and over 10 near dryness and in the process we precipitate these minerals such as calcite, a morphorous silica albite, and talc.

Working with the concentration of this fluid, we produce a carbonate acid liquid, a ph of about 6 at 100 degrees of 4.6 at 25 degrees and survives minerals where we are acting or this condensed water with welded tuffs and we get that field or the sparse area that Maury has just talked extensively about and the stability of this area and I won't spend a lot of time on that.

If the Vadose water is changed in any good extent at any great quantity of this water exists, it can affect its stability and in this case, we are looking at the clinoptioloite and instability increases with the increasing temperatures and get essentially dehydration and there's some question on rehydration and how long can you heat it up and what temperature and how well will it rehydrate and the major points that I wanted to make is during the boiling we increase the alluvia activity and the sodium activity relative

to the hydrogen and the aqueous activity or the aqueous activity ratio of calcite all of which decrease the stability of the clinoptiololite.

Also, with increasing silica we make it more stable and this essentially is overridden by these factors with the conclusion that with the disturbed zone potential, it may become unstable as boiling of Vadose water proceeds or if this water forms in any great quantity manages to escape from a disturbed zone.

Now, fairly simply calculation illustrates a serious problem and we think with the disturbed zone and this, we started out and that the preposity of about 11 years and we get about 7 percent water by volume and now with the Repository which is loaded with waste at this power density and actually this 20 max extension of dried out zone at the peak of the thermal alluvia 20 meters and there's actually at 100 degrees rather than 95 to 95 degrees which is boiling for this elevation and this may be somewhat larger or more of a conservative number here and from this we can calculate the volume of displaced liquid water from the zone that would be above the boiling temperature.

The area of the Repository is a 2,000 acre area and thickness of grid outzone 20 meters and this is the water contents and this gives you, we estimate, probably close to 10,000 acre feet of water which would be displaced around the Repository and you can assume that about half of this would be boiled and go above the Repository and this would form the perched water body above the Repository and above the cementation perhaps and this is quite an extensive body of water that may come back down on the Repository as the canisters cool off and perhaps cementation zone is fractured or otherwise ruptured, but I'm not sure of the scenarios that this may occur under.

But, the result as extensive developments around the Repository and perhaps the matrix saturation and along with this recharge flux would accumulate on top of this first water body and depending on what you assume for the recharge flux may be considerable.

As a result of all of these factors, we think it's very important that a site specific realistically defines the zones and be considered.

This is required to calculate ground water travel time with colloids and particular transport and in fact, it might be good to mention that another branch of the DOE has found that the colloids may travel faster than the ground will and don't ask me any questions, because I cannot explain how that could occur, has been one of their findings, up to 5 times faster than the ground water perhaps.

The extent of the disturbed zone or the mineral stability may be a factor in the extent of the disturbed zone and the changes of the Vadose water chemistry and the results from the disturbed zone or zones are needed for various calculations and to illustrate this point, I have a very extremely schematic diagram of the disturbed zone, but we have the Repository here and both lines represent fractures and the currently used definition of the disturbed zone is 50 meters and it's a non-generic definition and conceptual and this is what the NRC is proposing or has proposed using and that is what the DOE is working from.

And it's based strictly on thermal mechanical properties of rock as a result of excavation on the Repository and not in any changes in the fluid phases.

In fact, the DOE is trying to reduce the extent of this disturbed zone because it essentially reduces the water travel time, however, we feel that based on the processes that I have covered here, boiling refluxes and Vadose fluids and the others that I more realistically or a more realistic disturbed zone may be or to include the fractures and we can determine the extent that these become filled with water and what have you and with the simulation above the Repository, we'd have the first water zone up here.

Certainly all around the Repository is as a result of this drawing out and we'd get saturated fractures and perhaps saturated matrix but the disturbed zone may in some scenarios extend some distance above the Repository and in others it may extend

through the major absorption for the Repository of Calico Hills.

In conclusion, I think I have demonstrated that significant mass transfer could occur and this may have an affect from a mechanical stability of the Repository if you consider the volume and chances of silica policy marks it can be up to 4 percent overall value and reduction in rock and that may affect the mechanical stability and certainly the local changes and the preposity related to the zone permeation that we may get.

That as well as any significant changes in the Vadose water chemistry that could affect corrosion rates of canisters and the dissolution rates of waste formation and finally, the redistribution within any other Repository by thermal may result in thermal fracturing and if the formation of the locally saturated zones by concentration of fluid and I'll take any questions now.

DR. CANTLON:

It seems to me that part of the position of Nevada is that you are going to have substantial gas exchange through the breathing as well and so your model experiment or experimental model is a closed model and doesn't allow any loss of vapor.

MR. SHETTEL:

That's not strictly through initial experiments that were performed, but vented to the atmosphere, so you could lose water as well as gases.

DR. CANTLON:

You have got the same cemented zone and cycling.

MR. SHETTEL:

Oh yeah, it's all there, but there was a problem with it drying out and returning the water to the experiment and you can lose things such as CO2 and that that precipitates the change in the fluid chemistry as well.

DR. CANTLON:

But your return of the water seems to me is fairly artificial.

MR. SHETTEL:

Not with respect to what may happen as the Repository or as those vapors rise, they will condense and trickle down.

DR. CANTLON:

Or move upward.

MR. SHETTEL:

I think reality is somewhere in between and some vapors will move out as well as some will return and you will have the return flux coming down on top of that.

DR. VERINK:

That ph necessarily is limiting and you said you had maybe 6 and if you had radiologists and some leakage of air, you might get nitrogenoxide and a few more things that can make it pretty nasty.

MR. SHETTEL:

That was based on the concentration of fluids and it was just a calculation, but yes, as the thermal pulse warnings and you get water close to the canisters, certainly the radiologists produce nitric acids and these things could affect the stability of the canisters and perhaps the rate of thermal release in the canister and the waste formation.

CHAIRMAN DEERE:

How long is the thermal pulse that you're talking about which would lead to perhaps extensive fracturing of the cemented layer above the Repository?

MR. SHETTEL:

The fracturing may occur as the thermal pulse and the pulse is predicted to peak, I believe that 50 and 100 years after replacement of waste.

CHAIRMAN DEERE:

It must be a rather slow process of cooling down.

MR. SHETTEL:

I believe it would be, yes.

Possibly somewhat longer than the heating up phase.

CHAIRMAN DEERE:

As the water comes back in and trickles down in again in a somewhat cooler mode, would it cause precipitation on its own that might feel fractures?

MR. SHETTEL:

It could, yes.

CHAIRMAN DEERE:

Certainly we must be looking into that.

MR. SHETTEL:

These things need to be evaluated. We feel first of all, we don't know the chemistry of the Vadose Zone water and the model to calculate the changes in the Vadose Zone water is result of boiling or perhaps trickling down through the Repository horizon which are not adequate in thermal gradiance so the use of equilibrium models may not be sufficient to tell what's going to happen.

CHAIRMAN DEERE:

I believe we will move forward on to volcanism.

(Whereupon Eugene Smith takes the presentation podium at 4:20 P.M.)

MR. SMITH:

I'm Eugene Smith from the Department of Geoscience, University of Nevada, Las Vegas.

I'd like to talk to you today about some important issues concerning volcanism or volcanic risk at the proposed Waste Repository, Yucca Mountain.

I'd like to start off with introductory material and move on to important

issues regarding the site issues that we think are important.

Volcanism in the central Great Basin and in Nevada in particular is quite wide spread between 34 million years and approximately 6 million years and the next couple of slides show the distribution of volcanic activity.

The first one shows that this distribution between 34 and 17 in Nevada, this volcanic activity of all types and main distributed in a belt and central Nevada and Yucca Mountain is located approximately here (indicating) and most of this activity is mainly to the north of Yucca Mountain and Nevada Test Site.

Between 17 and 6 volcanism swept down into the area of the Nevada Test Site forming the southwest Nevada Volcanic Field and Yucca Mountain is located here and if you will notice that there is a gap between the southwest Nevada field and the Lake Mead area where there's apparently no volcanic activity occurring during this particular time.

For volcanic activity less than 6 million years, this is mainly what I was interested in. Volcanism is associated with 3 zones and one in the Lake Mead area and the fortification hill of volcanic field at the boundary between Arizona and Nevada, another area of volcanic activity along the Walker Lane Zone at the boundary between Nevada and California and also a third zone which is the Pancake Range at Death Valley extending in to the Yucca Mountain area and we have a greater flat area.

The next slide will show a portion of that. This is a portion of the diagram showing this particular trend where we are talking about and some of these ranges that we will be talking about later on.

I want to go through and show you where these are. The lunar crater area activity and the Pancake Range where the volcanic activity is, is between 5 million and approximately 3.7. Here's the Nevada Test Site and Yucca Mountain is located approximately right there and we have three major volcanic centers. There's a black cone

and a white cone and we will be talking about that and also Lathrop Wells Cone which may be as young as 20,000 and volcanic activity in Death Valley area, some of which is quite young.

I've noted that most of this volcanic activity is or I should mention that the salt of this particular field, the salt are closer to 6 million years and are slightly large than in volume.

We are talking about 5 cubic kilometers whereas the young volcanoes in the greater Basin flat area and Lathrop Wells are smaller in volume.

Most of this is alkaline salt volcanism which is initiated with the type of volcanic cinder cone which is a compilation of ash and volcanic ash formed by a strombolium interruption and was named after the Island of Strombolium in Italy.

The Strombolium activity builds up a cone of escar and the cone is as much as a half a million or three-quarters of a million and have very commonly the Strombolium activity which is related to other types of activity.

For instance, like Hawaiian style of activity they produce lava lakes and foundation stems and these may be formed early and are buried by later Strombolia and may in fact be in the interior of the cone and may form at a late stage of formation of cinder cone and form a lava length which occupies the central crater.

Sometimes the Strombolium type of activity can occur along with a hydraulic lake where magnitude comes in contact with the ground water and produces violent surge deposits and this type of cinder cone is produced by a variety of different types of eruptions.

We like to call the total cone or this cone is produced by all of the processes, a cinder cone complex and as craters in the greater flat areas and Lathrop Wells, we feel are also cinder cones complex.

There are some very important issues in question which I think have to be

considered with regard to volcanism regarding this problem and they fall into three major groups.

The first is structural control and the nature of eruption and then criteria for identification and in the volcanic field there are a number of ores but I want to emphasize those today.

Within category number 1, where volcanism occurs, it will be controlled by existing structures and future eruptions and will occur at sites of past eruptions.

The second category, how long will the elapse be or will it be simple or complex and are they reliable mechanical criteria that indicates its extension.

It's difficult to answer all of these questions by studying volcanoes in Lathrop Wells, but one has to look at some of the volcanic activity in the range and other areas to try and answer some of these questions.

So, we will be basing some of the answers I said in the discussion regarding these questions, not only on Lathrop Wells volcanoes but also on some studies.

Now, the first thing that I would like to mention or talk about is structural control. There are a lot of volcanoes controlled by regional structure and a lot of them fall or are very close to faults.

This needs to be - - this need not be the case. There are instances where cinder cones in fact may not be controlled by fault or fractures or conduits and it may in fact avoid the fault zones.

One example of this is the fortification field, 100 kilometers south of the west Yucca Mountain and this particular volcanic center is 4.7 million years old.

It erupted in the central portion of a mountain range and this is a typical basin range or mountain range in that it has bounding fault or major faults on the western side of the range and also it's not shown here, but on the eastern side of the range.

This volcanic or volcano erupted right in the central portion of the range in

an area where there are no map fractures and notice that at the floor there was grown down over the range margin and over the range margin fault without being off set.

There are no volcanic or in this particular instance structures had no influence on the localization of this particular event.

Possibly more important of a location of a fault and fracture is the sites of previous eruptions. We found that future eruptions may occur at sites where at past eruptions and the next we have two examples of this.

This is a little bit confusing because north is in this direction here. This is a geological map of Fortification Hill and this is one of the south volcanoes in the Fortification Hills 70 miles southwest of Yucca Mountain.

The volcano is controlled by the north, south trending Fortification fault that are parallel to this particular fault and the eruption occurred at this particular center for a total of 470,000 or 80 years and activity starts here and then migrated south and then continued for the remainder of the time in this particular area here. (Indicating)

This is only about a mile and a half of eruptions which were concentrated in this one area, for example, 470,000 years and the fault continues north for many miles and to the south for many miles.

Volcanism was focused into this one area for a relatively long period of time. One more example is closer to the Yucca Mountain side and this particular graph was not included in the package, but this is the red zone in the greater flat area and the central zone in the greater flat area is approximately a half a mile in diameter or the major zone is located right here.

However, when you look at the red cone in detail, you find that there's more than one volcanic center and we have located approximately 14 centers at the red zone.

These events are associated with three major trends in the northwest end and these are what I was talking about and indicated by the eruptions.

It's interesting to know that most of the flow of the red cones did not erupt from the red cone, but in fact erupted from this particular complex right here and now is quite highly eroded and not having that much topographic expression, I think that emphasizes the fact that in order to understand a geologic cinder cone, it's an extremely detailed map is required and doing probability calculations, it's important to count the number of cones and the number of events in order to get how many different individual events occurred.

Now, the point here is that for a period of time we are not sure how long volcanism continued in the red zone and we don't' have any good data or information on this, but volcanism is focused at this particular area and this is another example where if or for future eruptions occurring after the initial eruptions were focused in that one site.

If we started mapping at this area and do these eruptions last and the cinder cones. We spoke about the 470,000 years and recently Abstract and Brown suggested that in the central part of the great cinder cones are what we call polygenetics (pho.) cinder cones and have activities which list several thousand years and we are looking at events that or of that long duration and not events that last a year or less than that or ten years, but we are looking for something that occurs over a long period of time.

In fact, we can conclude that eruptions at cinder cone complex can last as long as 10 to 15 years.

You have already hinted at this, but in terms of nature of an eruption erupting at cinder cone complex, it can be complicated relatively from quiet down to moderately explosive and to Strombolian or I'd like to use an example of the black cone at Crater Flat and we'd map it in considerable detail and we have broken down the scoring on the cone itself into four individual packages.

Here's package four which is the upper 15 years or so of the cone in this

area here. We found many different changes in the methodology of the material of deposits which suggests relatively high Hawaiian or this cycle occurring over and over again.

In fact, the black cone we have mapped at 52 individual pulses and especially what happened at package 2 and 3, to the rocks in package 3 and general dip outwards or I'm sorry, the rock in package 2 and 3 and general dip outwards whereas package 4 and 5 they dip inwards towards the centers of the cone.

What we feel is packages 1 and 2 represent a wide-mouthed crater, possibly a crater formed by hydromagnetic activity and the crater was later filled by package 3 and 4.

More typically, the Strombolian and the less explosive type of Hawaiian type activity, but the entire crater is occupied by a lake and a detailed mapping is required to understand the nature of these cones and required before any sampling or geochemical can be done effectively.

Something else that we have to consider in terms of the nature of eruption is; we have to try to determine different types of activity and why they occur. We have said that most of it is alkali and salt, but is there any evidence that other types of activity have occurred.

We felt that to take a look at more possibly explosive activity which may occur, but as a result of this in the north of Yucca Mountain, about 60-kilometers or 70-kilometers to the north, we have mapped this area in and found that the salt in the Mill Valley Range can be divided into three episodes.

One, 5 million years old and one is 24 million years old and 3 is a slightly younger episode.

It's important to note that part of it has been remarked into volcanic plastic units, but this unit did erupt between the two alkaline salts and I'm thinking or I'm trying to

detail this and to find out whether or not this type of feature is common or relatively rare.

Also, it's for geological mapping and in an instance like this, before doing any collecting on geochemistry on an area like this, but that will be brought out in a couple of seconds again.

The last thing that I would like to talk about is, the possibility that there might be criterion or criteria for identifying extinct volcanic fields.

Previous authors suggested that volcanism becomes more alkaline as eruptions begin or terminate in an area. We suggested this may not be in fact through the eruptions, but they are more or less length varies and may not reflect the determination of such volcanism in any particular field.

Just to show you what I mean, let's go back to the level range, go back to a couple of diagrams and what we have here is a flat which characteristics is mineral which may suggest more volcanism up here.

If one went to this area and collected two samples or you went into this area and tried to find the oldest and youngest rock and simply collected those two samples and plotted the data up, you would see a trend looking something to that there.

Volcanism here is about 5 million years old and this trend is going from here to here.

You see this trend resets itself and many times we are talking here or what we are talking about may suggest the termination of an individual episode and may not suggest the termination of a volcano or volcanism in the entire field.

Let's go back and see if we have any answers or at least suggestions regarding some of these issues in terms of structural control, and like you said, I'm - - I know volcanoes are quite commonly controlled by structure cinder cones and may not have this control and in fact this may be more important in terms of future eruptions and may occur at or near sites of past eruptions.

Eruptions at cinder cone complex may last as long as 5 to 10 years. We are talking about very complicated types of activity eruptions that are involved and involve everything from relatively foundering to moderate Strombolian activity to possibly more explosive.

We are talking that possibly they are more explosive activity than may occur during or between, but also at the present time, we don't feel there are any reliable chemical criteria to indicate that that volcano is extinct and may not signify the death of a volcanic field.

We feel that all of these issues have to be considered when evaluating a Yucca Mountain as a potential Waste Repository.

Are there any questions?

DR. CARTER:

How well can we estimate the aim of volcanism, say 20,000 years or what kind of accuracy is associated with that versus the 1,000?

MR. SMITH:

The younger teacher is the more difficult it is to date.

Lathrop Wells, for example, techniques have been used in terms of traditional geological techniques have been used in isotopes that provide as I understand, the techniques involving geomorphic status, so indicating the younger cones is a very distinct or difficult thing to do.

For example, the cones that appear flat, one can use the more traditional techniques and there are types separate and for years to date, these with the higher accuracy of a classic rock types of techniques and in fact the rock dates may have errors of 30 or 40 percent as well as 10 percent.

Of course, the older the rock is for example Fortification Hill, the rocks are 5 to 6 million years, you can date those with analytical precision and the older the rock, the

better your confidence.

DR. CARTER:

All of those sound like pretty good accuracies.

So, if you're talking about one on the order of 20,000 years, you're talking about an error perhaps of 30 percent?

MR. SMITH:

The dates that are based on geomorphic evidence have the dates that have the young dates on like the Lathrop Wells job and I'm not sure that the analytical precision exists if it's based on or between cones and rocks, but in other areas volcanic fields, they have other techniques.

I can't really quote you analytical precision on the date to 20,000 year old data.

DR. ALFRED:

That's based entirely on the metamorphosis?

MR. SMITH:

I think there's a rock varnish date that does substantiate that.

DR. ALFRED:

What's the younger metric date that you have on one or the metric date and I know you will find that more tomorrow, but I believe it's 300,000 years on Lathrop Wells and the youngest date, I think they have is 1.1.

DR. CARTER:

What's the state of the art now?

I notice that you have stayed away from that in predicting volcanism in terms of time and also variance.

MR. SMITH:

I think it's premature to do a probability calculation.

I don't think we know that much about the assumptions to do a probability calculation.

The probability calculations that have been done up to now are based, I believe on assuming distribution and I can't talk about that in detail, but the - - these do not appear to be met by calculations that have been done in the Yucca Mountain area.

I think we have to be or do more work and define the probability calculation techniques before we can come up with values and it should be discussed.

DR. CARTER:

Are you saying that there are no current model or models that people would use or the State of Nevada could be comfortable with protection in terms of the region or terms of - -

MR. SMITH:

At the present time, I'm not comfortable with it, yes.

DR. CORDING:

The episodes that you show, are they common to a field or to a portion of a field?

MR. SMITH:

This is common to the range and common to the field scientists that extend their work in other areas adjacent to find out maybe that these trends can be traced up to show on that diagram are valid.

DR. CORDING:

But I'd say that within a given field, you'd see that most of the cones would be in that portion of the episode, isn't that correct?

In other words, if you look at most of the cones within a field, they would all be at the same point in that episode in terms of their content with respect to the others?

MR. SMITH:

Generally the cones are formulated and presumably.

DR. CANTLON:

What's the size and, are you talking about in acres or 10 acres or 100 acres?

MR. SMITH:

This one or the reason that we choose this is there's a considerable amount of erosion and you can see 2,000 feet beneath the volcanic centers and the events are very narrow and the digs are no more than 4 to 6 feet or maybe I guess the widest are maybe 10 feet across, but they do extend for fairly long distances.

These here extend for several miles. They are not continuous, but very narrow features and in a way it's sort of amazing that so much material was pushed through such a narrow dike, so we are not - - this particular events widen out once they reach the surface within the cinder and cones and they begin to widen out in the sub-surface.

DR. CANTLON:

So, sketch for me a worse case scenario if you get a tube coming up through the center of this Repository after it blows up, what would you visualize happening?

MR. SMITH:

You're asking me to predict the future.

DR. CANTLON:

No, tell me from volcanism what would be the actual kind of activity because the lava drive comes from the deep depth and is moving through at a pretty good clip and if it intersects through a Repository and entraps some of the waste and carries that on the surface.

Some probably would.

MR. SMITH:

This is one of the reasons that we have to understand the nature of these cones and if in fact there's a hydromagnetic event, this would result in an explosive

eruption and that may exclusively distribute some of the waste and do more damage to the Repository than having a dike being driven through it.

We have to map these features in detail to find out how common these hydromagnetic events are. We have to understand deposits in order to answer the questions that you're asking.

DR. LANGMUIR:

Just assuming momentarily that all of these dikes represent an explosive type of possibility, what percentage of areas around Yucca Mountain have been impacted by that kind of event in the last million years or so, 5 years or 2 years?

MR. SMITH:

All I can say is the hydromagnetic events associated with Lathrop Wells, we have a feeling that the eruption may have a component of hydromagnetic activities.

And also the Lunar Crater area which is a mild crater formed by magna and water, so it could very well be initial eruptions on most of these, but we don't know yet.

During the Rifle Range, the initial eruption search deposits that I hinted at and our hydromagnetic origin also, but the main fact was the initial phase of eruption for most of these cones and we don't know yet.

DR. LANGMUIR:

I'm speaking of the probability that this could happen at the site under the worst condition.

In other words, what percentage of taking the mountain area having impact at some point?

MR. SMITH:

Yucca Mountain block?

DR. LANGMUIR:

Yes, except for a couple of dikes, Yucca Mountain have been impacted at

the present time?

MR. ALFRED:

Certainly if we assume the entire zone is likely to erupt anywhere within it, this easily could be a subject of treatment as it has been, but anything is subject to probabilistic type of analysis that would be, so would this be.

MR. SMITH:

You have to make sure the assumptions are proper for treatment.

CHAIRMAN DEERE:

Thank you.

(Whereupon Martin Mifflin takes the presentation podium at 5:00 P.M.)

MR. MIFFLIN:

Very rapidly, I'll try to go through general concerns associated with climate change when dealing with a Vadose Zone Repository and the Great Basin.

We have two principals concerns and those are that a climate change to a type of climate has occurred periodically in the Great Basin and is quite detailed in characterizing with the existing data for the last 16 to 10,000 years of time, which is a type of hydrological effects of these claims which are rather profound in the studies as seen now and based on the type of qualitative and the other data that's already existing, we judge or people have estimated including myself and others, that there would be something like a change in effective moisture of about 10 and the current effective moisture is kind of a rough name for that moisture that enters into the hydrological site, either recharge from the ground system or surface water run-off, so it's the net that gets passed that effective moisture.

The question about site specific impact at Yucca Mountain becomes a rather challenging and scientifically interesting item because most of the evidence isn't

there or at least we don't know much about it, so I have decided to break this talk up into briefly what we can do in terms of site specific evidence and what we can do in terms of regional evidence.

The regional evidence that is best documented at least is in the form of deposits and associated features that occur in the graphically closed basins and in the southern part of the Great Basin where even during the peripheral conditions which were relatively arid and deposits that we now understand to be related to extensive areas of ground or discharge from or you will see some on the way out to the Test Site.

There is a map of Yucca Mountain which is right at this location and the shaded areas are the former extense of the poluvio (pho.) lakes that occur essentially in this extent up into about 18,000 or so years ago and later to reduced volumes up until about 10 to 12,000 years.

If you will note where the little red dot is, Yucca Mountain area, we start to run out of these poluvio lakes and they get small as we go to the southern part of the State and based on analysis of the size of these water bodies at full development and the size of the geometrics and the hydrographic basin, 10 times effective moisture value has been dry and that's one way quanitatively that they have occurred by comparing modern day lakes to a few of them and basin size versus full lake size which is a measure of a continuity of putting the basin out so that we get a value of 10 to 15 times.

This is a little bit of a blow up of a different source in Yucca Mountain again and these are the southern most lakes that were mapped on the criteria and well defined shore lines and preserved land surface and these little hatched areas are the extent of what I call, "Ground Water Discharge Deposits," which are about the same age which the State program has been actually looking at, because these indicate a position of saturation in much greater flux of ground water discharge, which is pertinent to the question of Yucca Mountain as a reasonable - -

CHAIRMAN DEERE:

What do you mean by the, Deposits of Ground Water?"

MR. MIFFLIN:

These are types of deposits that occur in every basin that are generally quite fine and they are light colored and they are usually like silk sands and clays and they have for many, many years been called Lake Beds, but it turns out on a detailed study that they are wet meadows or meadow ponds or shallow marshes and some types of units are the types of deposits that from around the neophyte plants that are put there or have their feet in the water, but the sediments are locally derived.

It's kind of an aggravation.

CHAIRMAN DEERE:

Sort of swampy ground water discharge?

MR. MIFFLIN:

In many of these areas there is no ground water discharge or it's extremely reduced in some areas.

For example, in this area here right here, 3 or 400 feet to first saturation is the same or the same is true with the extent of the former dry lakes.

For example, in this particular area, at least 4 or 500 feet of saturation right now and this is not always the case, but each basin appears to have different local controls, so one just can't take the difference between then and now and say that this is what it would be at Yucca Mountain in terms of State or in change of the level of saturation, but it gives and idea or an order of magnitude of the differences in the State hydrologic system that we are operating between, say a full dry climate and the least affective moisture climate that we have now.

DR. CANTLON:

None of these surfaces are playas that are temporarily wet in the winter

time?

MR. MIFFLIN:

In many of the former lake areas, we have what is now a modern playa, but the extent of the lakes are greater than the playa extent in most cases in southern Nevada and we have no evidence of former lakes here.

I brought this back in because based on regional evidence, it's 10 times a valid number and you recall this is based on very conservative assumptions that the recharge is distributed across the Repository and evenly in space and time and then you multiply this, the value up here of some of the most modern recharge but 10 or 15 times and this is what it would do to your - - let's say, we multiply this conservative value of 1/2 millimeter by 10 or we are up here by this one, so on what this change and effective moisture does is; it pushes it away for in terms of the matrix versus the fracture flow is what the concern is and what the original evidence in a general way is, you get a Vadose Zone Repository sitting right at the top of this system and in terms iof sensitivity to a climate change and if it's through a more humid climate, then it is less likely to continue to exhibit the waste size saturation or the characterization it has right now.

Now, that being at least posing the question then the more site specific information with great interest to see whether there is any direct evidence that would suggest how such a general frame work of a poruveial climate might have behaved.

There's only two good majors that we recognize, at least in this point and time and that is the agenic minerals and their distribution and the Vadose Zones altered by moisture presumably in the past and the macrofosil evidence that is also so called pack rat in the relatively arid environment and these nooks and grannies and their preservations of these systems up to 50,000 or more years in age which are incorporated in the different areas and various samples of our surrounding vegetation and analysis of those such as Carbon-14 and those vitamins give a site specific glance at a point in time or a series of

points in times that the midden is very old and prolonged.

What the plant communities were at that surface or at that point so that would be one.

One form of characterization and directly by vegetation if site specific climate at some point in time and the other less sensitive areas at this point in time, but are more direct interest in terms of site characterization, is the occurrence of the osteogenic mineral and fractures and where they are when they form.

We are looking at that, but so far we don't know how successful one can fine down in terms of mineral formation.

There's some with respect to distribution of and this is not a good slide to show this, but the blue line is the modern division of the water table and you can see yellow above it.

Those yellow zones are or could be related to and at least we think they are probably related to coleo (pho.) water tables and probably once were fresh water or part of the problem is that it's not fair as to what is required to alter those and how much moisture or whats is the saturation water vapor doing, etcetera.

What is informally called a favor water table is geographic extension and configuration and looks pretty good and the alteration based on the data base that exists, but it's about this one right here and there are other zones where there have been described as grass alteration and higher up those probably or they could be related to perch water and not fresh.

Very quickly, this is the way in which the pack rate midden data and the water or the ground water discharge deposits form and the poluvio information correlated with respect to time and basically the different approaches in which the snapshot, if you will, of the formal climate is established.

Here we have lake level and based on the stratigraphic relationships and

some Carbon-14 and we have ground water discharge deposits in this particular record book which has been established very close to where the field trip will be showing that back about 20 or up to about 16,000 and in this particular site there was exclusive margins that went through a period of time where there was still ponds and shallow saturation based on site identification and the microfoscils and the changing environment to a more reduced wetness and about 7,000 or so of such went over into the validity of closer to the present climate.

Here we see the by virtue of a diagram of different kinds of plants and their importance in their historical middens from different age from day to day.

We see that the community plan or the planned community is changing with time and we saw the lake level changing there.

In summary, we are concerned that the climate change to a more rudder climate, pushes everything the wrong direction with respect to the type of profit one must call upon at Yucca Mountain and to keep the travel time long, because as you put more infiltration, you are forcing it more into a fuller and more extensive fractural type of state and the change of or apparent change is a magnitude that it's just not within the noise, but a substantial change based on what information we have now.

Any questions?

DR. LANGMUIR:

The interesting thing is to look at your next to the last illustration which suggests at least, although some of the information is dashed, but how rapidly these changes occur based on history.

MR. MIFFLIN:

That's in part an artifact of the artistic license here, but not really when you start, I mean, there's a little bit of licensing on a drawing where these lake levels are, but clearly the changes occur with 1,000 or so years and changes very rapidly, so we don't

have evidence that that's repeatedly or there's been changes and they don't necessarily occur over a natural period of time in terms of the pack rat midden data, but there is some evidence that the plant community doesn't respond as rapidly as majors in the hydrologic system and right now, the State is supporting work that is blocking or looking at this aspect, but it's kind of a side aspect of interest that the plant communities may not be as sensitive as some of these other majors.

DR. CANTLON:

The recent identification of the great Salt Lake, does that give you a view of how rapid those water level change?

MR. MIFFLIN:

Where there's tremendous damage and concern over the past of what was it, 4 or 5 years ago, now shows why a climate or a very modern or minor modern climate has a profound hydrologic effect in terms of effective moisture and in these arid climates, so what looks like a very drastic change in terms of modern climate, they are very dramatic in some cases and so we go from let's say a small amount of effective moisture to a very substantial suspect moisture with a very small climate change to make.

One quick point is in the case of the analysis of the alluvia waste, I tried to estimate what the change in climate was on a precipitation modeling and the function between mid and full temperature based on 15 types of climate in the Great Basin and it came out with a change of only something like 5 or 6 degrees Fahrenheit reduction in temperature and 80 or 90 percent increase in precipitation to recreate those lakes which gave 10 times or more effective moisture which was kind of a conservative analysis, so I tried to put the minimum values.

DR. LANGMUIR:

Is the lake issue the same one as the Yucca Mountain in the case of a lake or you were looking at the run-off concentration in a system to accumulate whereas you

have run-off on the side if you're looking at it relative to the topography or if you have no run-off?

MR. MIFFLIN:

That's the reasons that we have beenstudying very carefully the ground water discharge because the, just as you say surface water hydrology may be has nothing to do with hydrology, however, in southern Nevada the ground water discharge deposits has everything to do with ground water and it is in the same type of climate particular zone and Yucca Mountain and we are seeing a similar but much more difficult to quanify, but similar increase in areas of discharge.

DR. CANTLON:

As you go to more humid areas the surface hydrology which are much more linked than they are at this point or at this one?

MR. MIFFLIN:

That's correct.

It would appear that what a preliminary analysis we have done in terms of ground water deposits, it looks like they are in the same order of magnitude or something like one or magnitude greater.

It's more difficult.

CHAIRMAN DEERE:

Thank you.

Let's move on to the last speaker.

(Whereupon Lawrence Larson takes the presentation podium at 5:20 P.M.)

MR. LARSON:

My name is Larry Larson and I'll giving this presentation for work done by myself and Steve Low (pho.)one colleague who is here.

We have been directing our comments today on mineral resource potential and what we know of what needs to be known of it for Yucca Mountain and the immediate vicinity.

There are two questions that we want to address and specifically; is the potential for mineral resources in and about Yucca Mountain and if so, this 1,000 to one of the potentially adverse conditions of NCFR.

The other is, will there be human interference at Yucca Mountain and if so, we believe it will fall into a consideration safety analysis report of NCFR 6.

In conclusion or our conclusions are existing data that are insufficient at least in our opinions and those steps by the DOE proposed to take insight as best as we understand, will not be sufficient to provide the information that we need.

That's our contention.

This are that I'm going to be talking about and for your identification, this is Yucca Mountain here which is G-1 and G-2 and G-3 and we have highlighted various areas of mineralization around there and this is just to focus you on the comments that I am going to make here.

In the summary of your answers at the start of the presentation and at Yucca Mountain is very or is considerably wide spread which looks at the highlighted areas currently there is mineral exploration and has been for the last 3, 4, possibly 5 years with development or development but in any case all areas surrounding Yucca Mountain are open to entry and that basically means from over here.

If some of the areas to the east of Yucca Mountain were open for mineral entry, I'm confident that there would be activity programs or protection from wahmonie.

So, the existing information, we feel is completely inadequate to evaluate the potential for mineral resources in the Yucca Mountain area or the immediate vicinity.

I'm not sure what I mean by immediate, but I think that's for someone else

to define in some sort of a legalistic term.

It's impossible to rule out the fine mineral resources in Yucca Mountain because the data base is completely insufficient.

Historically, where there are mineral resources, there is human encouragement by exploration and the next just gives you an idea and I'm not going to try to take the presentation now from the broad sale to the area specific to the Site, but this is the broad scale and the only one of its nature and this is in 1978 to 1988 the precious metal products in the State of Nevada.

Most of you know and if you don't know you will in about the next two seconds that we are at a country where we are not producing at the moment and we would be the 5th largest gold producing in the world at the present time and there's been a 17-fold increase in gold and silver production in that 10-year period and that gold and silver production did not come without preceding and on-going exploration of this sort.

We are seen in the general southwest Nevada volcanic field in and around Beatty and Bear Mountain and many other places, there's a relevance that the more you look for it, the more you find it.

If you start finding it, you want to stay there because you are in elephant country.

Now, for more common geologic features of Nevada or deposits or what do you look for. These are a few of them; rock alteration or change in the rock perhaps could be produced, hydrosolidified (pho.) and they stick up out of the ground, see (referring to the diagram) and things like that.

They don't stick up out of the ground very well and you have to look carefully and develop them, but these are the typical rock saturations around certain types of Nevada ore deposits in the particular areas or deposits that we find in and around Yucca Mountain.

Rather typically since these are precious metals, obviously they have mercury and barite and fluoride. I'd like to have you keep these in mind so when we get down to the area of Yucca Mountain and ultimately to Yucca Mountain itself, you will see what I say here and I will repeat myself that the faults and creases have to be areas on the increase and they may deposit their load to form deposits and usually it's a faulted area with great ground preparation for or favorable dikes plus stock and things like that.

A lot of times you will find these minerals.

Now, let's get a little more area specific and say okay, now what have we got around Yucca Mountain at the present time or what kind of distances and since all of this is closed off for human incursion, I guess, Yucca Mountain here, we have the first one which is the Sterling Mine which has been in production for a number of years now, 10 or more.

The reserves are 75,000 or roughly 30 million dollars. That's within 10 to 12 miles from the proposed Repository.

You can see it very nicely and I will show it to you Wednesday.

We have the Gold Bar Mine considerably further away, about 40-kilometers, 62,000 ounces or 25 million.

Next, we have Bond - Bullfrog - -

DR. ALFRED:

What kinds of rocks are these?

MR. LARSON:

I'll get to that in a moment, if you can wait, Clarence.

The next is the Gexa Mine which has those reserves and the biggest elephant of the elephant country is the Bond-Bullfrog Mine outside of Beatty and in answer to your question earlier which was, whether it was a worthwhile effort over a billion dollars, of course, all Australians are correlating, so I don't know about that.

This is the Bond-Bullfrog and right now, it won't be in a few years, but actually one of two pits will be in the middle ground here and this is the mountains here and there probably won't be any more, but I think that's true and so this will be one large hole in the ground.

Now, going back to the picture of what are the features of the mines and the prospects.

For example, at the Bond-Bullfrog and at the Gexa and at several other properties and at the Transvaal there are vein deposits such as the Wahomonie deposits which presumably is in contact with curious rocks and other rocks which are varied and you can see those are geologic types and you might see these and these are the chemical types of predominantly precious metals, not all mercury, but interestingly, lots of little mercury and there's a little gold over here too.

We'll show the rock samples that we took from these and the deposits over here. We can see that there's a variety of both chemistries and in answer to your question Clarence, there are a variety of host rocks of deposits here.

These deposits at Bullfrog hill are hosted in you might say the Paint Brush for equivalence and the Gexa deposits and the tuffs and the paleo rocks and also the mountain deposits are prospects and the Calico Hills.

There's a variety of types of rock and ages of rocks which are present. The hyrothermal alteration which I'm going to repeat what I said, the solidification and a number of these places such as Calico and Bond and Bullfrog and so on.

There is development of clays at many of these and we can, I guess, on the field trip they won't permit us to go there, but we can show you these things and the geochemical significance and again this is shown in what is elevated and what the potential is for gold, silver, etcetera.

The new or the things that you look for if you are in exploration is you look

for precious metal deposits with favorable structures or high angle structures or low angle structures and there may be flat structures, but there are probabilistic structures and there are detachment faults both hydrothermal and the tectonic breaches and there is contact between rock types and also favorable for mineralization.

Now, remember that I said that up in the northern part or in the general area right on the north and west portions of Yucca Mountain that we decided to take samples and these are tuff analysis of the sample that we have taken that were done by Geochemical Services Incorporated who have quality assurance programs in existence and they are done by introductory mythologists who are not going to mine any of these samples that you will find any exploration is worth its salt present today and we'll find this value here to be of extreme interest and worthy of much follow-up.

There are many times that normally would be found in rocks of the nature that these were taken from, we are looking at anywhere's from 400 to 2,000 parts per million in terms of mercury in these volcanic rocks.

Clearly, elevated, we don't like to use the word, "Anonymous," because we don't have sufficient sample to give statistical background and threshold, but certainly it's elevated over anything that you might reasonably expect. So, when you look at the mineral potential of Yucca Mountain area, this is the area surrounding Yucca Mountain and there's a favorable geological environment for hydrothermal mineralization and repeated magnetic and volcanic activity which is indicated by the outlines of this and some of the others and also this is possibly mineralization which is fault controlled with faults forming along possibly perpendicular to the margins of Caldera Complexes, but I can't guarantee that.

There are producing mines and as I have said before, if you are in elephant country, that's where you ought to be to look for more.

Gold Bar and Bullfrog is presently working and these two aren't presently in

production, but actually will be and favorable protection and some of which are outside of the Test Site and some of which from a capitalistic view point are inside the Test Site and possibly will never be accessible, at least while you can put guards around them.

Let's take a look at Yucca Mountain rather than around what features are present there and what is pertinent to mineral potential for this.

We are using, since we have not been able to access any of the core or drilling of various regions of logistics and whatever we are using, that has been done by others looking at the core and published by various national laboratories and the U.S.Geological Survey, they have said between G-1 and G-2 cross-section from the solitarial canyon fault over to Fran Ridge here and later, I want to pay attention to Bull Ridge, which we have highlighted in an area of potential alteration or more than potential and it has been reported to be quartz favorable.

We don't know how extensive this is, but we have G-1, G-2 and G-3, but only one of those go to the paleo sonic, yet we have got Calico Hills mineralization and we don't know what's down there and here's our possible salt fault separating the contaminants and rocks and finally we have gotten out of somebody that we are short of waving an arm and saying to a certain extent that this alterations are up with some of these fault zones and we are sure in one case that it is.

We have data that shows elevated floriberian zinc and gold at depth and in drill holes, but are of geological interest.

The age of the hydrothermal activity is 10 to 11 million years and this is the age of the rock which is 13 to 16 million years, so the rocks were crystallized, solidified and cooled at least before hydrothermal alteration and mineralization in its subsequent future.

The hydrothermal activity of mineralization is the same age or close to the same age as the hydrothermal activity mineralization in the Bullfrog Hills and the Bond

and Bullfrog and other mines that we have tried to show.

This is the Yucca Mountain and that is to 10 to 11 million years alteration where we have intransvaal northwest Yucca Mountain and here's the northern Bullfrog area and around Beatty, so this is a mineralization event at the same time that we have got data regarding the tuffs in Yucca Mountain and other things.

Yucca Mountain was not excluded.

Now, volcanic units or rock units at Yucca Mountain at the point in time have the same sequence of events, specifically the same ones that we don't know yet, but the same sequence of units of gold, silver and carbon at Bullfrog and elsewhere in the presence of numerous faults and pressures at Yucca Mountain that provide a lot of circulation and go back to this for a second here.

These, "High Terminability channels," this is a pictures of the south wall of a trench that you will be seeing. Someone else took this, not me. I'm not allowed to.

The picture nonetheless, of what you are seeing is just the trench expression from here. Now, this is mineralization and all of this is probably most of it is what you are saying is mineralization, but again, we don't feel all of it is.

When we go out to the field trip we will see the features and it's on the opposite side of the trench where the person took the picture is standing, that we sampled and we got numbers such as this on 8 different samples and again, it's not ore, but half parts per million silver.

If you look at the mercuries, it's up to 3,000 parts per million which is several times what it would normally be in the Tiva Canyon.

Something happened there that the hydrothermal system was metal bearing and how much metal, we don't know.

So, the conclusions that we have to make at this time are that the recent discoveries and new geological data we have and have been available to require from

others suggests many great mineral potential exists than previously recognized for the area, possibly for the mountain itself.

Now, without starting to recognize this and once the greedy American finally gets interested in this, the exploration activity is going to increase and we have seen claimed activity on Yucca Mountain which has not been turned over conveniently to people who wish to have them, but there is alteration mineralization and if humans don't interfere, if they are not the kind of humans that I know of, but if you don't put wall to wall guards around at the NTS area and the existing data do not exclude the possibility of economic mineralization and insofar as near the Yucca Mountain area suggests the likelihood of it, but we do not know about Yucca Mountain because we don't know yet.

There is no plan and very little planned information is to be derived from the paleozoics at all, which stresses me to no end.

The resolution of this issue requires rather fundamental geological and I don't think or mean in an ivory tour sense, but investigations which are conducted from an exploration point or if someone takes a look at the gold deposits in the State of Nevada, the entire gold deposit, many, manyof dollars could be encompassed in a football field, but typically when you're trying to or whether a deposit is there or not, you drill it at least in 100 foot sectors.

I would like to ask people what is being considered now for the term of Yucca Mountain.

DR. BARNARD:

On one of your view graphs, you have got 4 mines listed, Bullfrog, and you have a little over a billion dollars, is that in the value of all of the reserves there?

MR. LARSON:

That's the announced value of their reserves.

We calculated the price at 400 and it's now 375.

DR. BARNARD:

So, if a similar deposit were found at Yucca Mountain and the cost of the Repository would increase 15 billion dollars to 16 billion dollars, is that right?

MR. LARSON:

That's your comment, sir.

My comment is that in the regulations which guide studies on these are adverse.

DR. CARTER:

Are you going to comment at all on how to or how the hydrocarbons are - -

MR. LARSON:

I'm not qualified to talk about hydrocarbons.

Thank you.

CHAIRMAN DEERE:

Thank you very much Mr. Larson and Carl, we want to thank you for having these technical presentations.

(Whereupon Carl Johnson takes the presentation podium at 5:50 P.M.)

MR. JOHNSON:

I would like to take a few minutes and summarize what we have heard today.

I hope that we have been able to successfully get across some of our points concerning Yucca Mountain Repository site and I think one important thing that needs to be brought out is that with the discussions today, they have centered and many cases on studies that we need in the State and have undertaken as an adjunct to a review of the Department of Energy's information that certainly does not apply or imply in any sense of the imagination and I want to make sure that this is clear to the Board, that the State of

Nevada is not in the business of characterizing the site.

Clearly, as embodied by the Nuclear Waste Policy Act, the burden of proof of determining whether this is a suitable site and licensable site totally rests on the Department of Energy.

We are doing studies to help assure ourselves as to the whether or whether this is a suitable site or not a suitable site.

With that in mind, earlier this morning and my remarks almost 8 hours ago now, I talked about 4 general site suitability concerns and I think I can summarize that by saying that all 4 of the various concerned areas that I talked about are inter-related and all the issues that are or that I raised this morning will certainly have to be addressed and resolved before we ever conclude the licensing and construction of a Repository.

With that in mind, I think we can make general observations from the discussions that we have heard today.

One is that the southern Nevada area is an active area geologically, tectonically and geohydrologically and Yucca Mountain is tectonically and geohydrologically a complex area.

Thirdly, that collection of adequately reliable representative data to resolve some issues may be discussed and may be difficult if not impossible with the current state of the knowledge.

Lastly, there's some major question of the prediction of site performance over 10,000 years and I come back to the term reasonable assurance and that may not be possible at the Yucca Mountain site and given these other observations and lastly, I think we in the State can make the following conclusions and one is that the Yucca Mountain site has not been to date, determined to be a suitable site for isolation of high level waste and secondly, it is questionable whether the demonstration of suitability and reasonable assurance of isolation can be achieved, especially within the time frame that the

Department has proposed. With that, I will take any remaining questions that the Board might have.

CHAIRMAN DEERE:

I think your conclusions are very clear.

MR. JOHNSON:

With no further questions, I thank Bob Loux who had to leave for another engagement, and myself on behalf of the State, would certainly like to thank the Board for allowing us the 8-hours today to make our presentation and to thank most of the presenters who were here today and who will also be on the field trip on Wednesday, so certainly there will be some opportunity to continue some of the dialog that was presented today.

CHAIRMAN DEERE:

Thank you very much and we certainly will be getting back to you again for additional discussions in future months, plus we look forward to our discussions tomorrow and in the field again with all of us.

(Whereupon meeting was adjourned at 5:55 P.M.)