ORIGINAL ACNWT-0080

OFFICIAL TRANSCRIPT OF PROCEEDINGS

Agency: Nuclear Regulatory Commission
Advisory Committee on Nuclear Waste

Title: 61st ACNW Meeting

Docket No.

LOCATION: Bethesda, Maryland

DATE: Wednesday, February 23, 1994 **PAGES:** 1 - 277

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UNITED STATE NUCLEAR REGULATORY COMMISSION'S

ADVISORY COMMITTEE ON NUCLEAR WASTE

DATE: February 23, 1994

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UNITED STATES OF AMERICA

NUCLEAR REGULATORY COMMISSION

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ADVISORY COMMITTEE ON NUCLEAR WASTE

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61st ACNW Meeting

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Nuclear Regulatory Commission
7920 Norfolk Avenue
Room P-110
Bethesda, Maryland
Wednesday, February 23, 1994
8:30 a.m.

ACNW MEMBERS PRESENT:

Martin Steindler, Chairman
Paul W. Pomeroy, Vice Chairman
William J. Hinze
B. John Garrick

ACNW STAFF PRESENT:

Richard Major
Howard Larson
George Gnugnoli
Lynn Deering, Designated Federal Official

ACNW CONSULTANT:

Ken Foland, ACNW Consultant

P R O C E E D I N G S

[8:30 a.m.]

MR. STEINDLER: The meeting will come to order. This is the first day of the 61st Meeting of the Advisory Committee on Nuclear Waste. Present at this meeting are, to my left, Paul Pomeroy, Bill Hinze and John Garrick, as members of the Committee. I will get back to John in a minute. Ken Foland from Ohio State is the consultant to the Committee. In addition, we have with us the Advisory Committee staff. On my right is Richard Major and then followed by Howard Larson, George Gnugnoli and Lynn Deering. I will get to John further.

The entire meeting is going to be open to the public. Today's meeting will include a briefing by the NRC's NMSS and research staff and a discussion with the staff on the current efforts on volcanism and volcanism related to specifically the high-level waste repository.

In addition, we are going to be briefed by the NMSS staff from the Division of High-Level Waste Management on their topical report review plan. Finally, we are going to discuss with the Office of State Programs their position on the compatibility issues with regard to agreement states. Today's meeting is open to the public and is being conducted in accordance with the provisions of the Federal Advisory Committee Act. Ms. Lynn Deering sitting at the table is the designated Federal Official for the initial portion of the meeting.

We have received no written statements or requests to make oral statements from members of the public regarding today's session. However, as is our custom, anyone who wishes to address the Committee should make arrangements to do so with Lynn Deering. Thank you.

It is requested that all of those who speak use one of the microphones and identify himself or herself and speak with sufficient clarity and volume so that he or she can be readily heard. Before proceeding with the first agenda item, I would like to cover some brief items of current interest.

I want to welcome our newest member, John Garrick. He was recently appointed as a member of the Advisory Committee on Nuclear Waste. John is trained in physics and engineering and applied sciences. He has a Ph.D from UCLA. He attended the Oak Ridge School of Reactor Technology. He worked as a physicist at the National Reactor Test Station which is now known as INEL. He spent a little less than 20 years at Holmes and Narberg where he was President of the Nuclear Systems Science Group, and for about the last 20 years was and is President of PLG, Incorporated, a consulting firm of engineers and applied scientists. John is an internationally-recognized expert in probabilistic risk assessment. He has published exclusively and extensively on this kind of subject. Last year he was elected to the National Academy of Engineers. We are most pleased to have John with us and look forward to comments and the content of deliberations that he is going to engage in.

MR. GARRICK: Thank you.

MR. STEINDLER: Secondly, I want to welcome John Minns at the end of the table, on my right, who is a three-month rotational assignee to the Advisory Committee Technical Staff. John is a health physicist and attended Columbia University and Catholic University, and has degrees in chemistry and nuclear science. He has been at the NRC for about 20 years. He is currently looking at the international waste activities and updating a 1990 Committee survey on that subject. He is also looking at issues associated with the multi-purpose container that the Department of Energy appears to be aiming toward, as well as looking at issues in the natural analogs field. If he can accomplish all of that in three months, we should serve him as an example to the rest of the staff.

[Laughter.]

MR. STEINDLER: I want to draw your attention to the considerable amount of publicity that has been afforded to the 1995 budget request by the Department of Energy for the Radioactive Waste Management area. That request shows an increase in total dollars that goes from the current 381 million for fiscal '94 to 533 million in fiscal '95. That is a 40 percent jump in waste dollars. This is to be obtained by monetary manipulations which, frankly, I don't understand. But, I wish Dan Dreyfus, who heads the activity for DOE, all of the luck in the world to be able to pull that off. On the other hand, I think it is perhaps necessary to point out that an automobile doesn't really go faster when more gasoline is poured into the cylinders. You really have to have acceleration by a means called advancing of the spark. There may be some lessons to be learned from that analogy.

Last and certainly not least, I think we need to congratulate our Executive Director, John Larkins, to whom the NRC has presented the Civil Rights Award for his outstanding contributions to the Agency in the area of civil rights and equal employment opportunity. Where did John go? Congratulations, John. He didn't even mention it. I had to find that out by some round-about fashion.

Are there any other areas or topics of interest that we should mention?

[No response.]

MR. STEINDLER: If not, let's turn to the first item on our -- being eight minutes -- I want the Committee to understand we are eight minutes ahead of schedule. That will be the last time I think today we will be ahead of schedule -- to our first topic of interest, and talk about the current efforts on volcanism-related activities.

Before we get started on that, I think it is important perhaps to make a few comments about what we are about. This Committee has re-examined of late, as those of you who have spent time watching us I am sure know, the way it conducts business and the business it conducts. Both have been changed lately to accommodate to the needs of the Commission and the Commissioners. We plan I think to become more emphatic about the impact of what we discuss on decisions that come directly to the Commission and the Commissioners. And we plan to identify those problems, and we hope we can also provide suggestions that we believe that the Commission should or has on their plate, both in the short-run and in the longer term.

Further, we have, as some of you know, re-defined the scope of our activities and, with the help of both individual Commissioners and others, we have defined a qualitative, prioritized set of topics. That set of topics has been reduced in number to a fairly modest and we think workable size. The result of all of this we think should be a more focused discussion on problems and solutions and the status of many of the activities that deal with radioactive waste. We continue in this vein to solicit comments from all of those who have something to contribute to us in order to be able to move the program forward as much as possible.

I think at this stage of the game I simply want to point out that it has been our practice to assign lead Committee member status to any one of us for various topics and, in this case, Bill Hinze is the lead for this topic and he will essentially conduct the meeting from here on out. Bill?

MR. HINZE: You weren't kidding. Thank you.

MR. STEINDLER: No, I wasn't kidding. You may make whatever introductory --

MR. HINZE: Last year, as I am sure most of you are aware, the Committee reviewed the general aspects of the draft NUREG 1406 on the High-level Waste Research Program. As a follow-up to that review, we will be investigating over the next several months, the various plans and progress for research in a variety of different areas. Hopefully everyone is awake now? Let's continue on, if I might.

Following up on our 1406 review, we are going to, in the next several months, review various phases of the research program in a variety of disciplines. One of those that is of considerable current interest to us is the issue of the potentially adverse effects of volcanism at the candidate high-level waste site at Yucca Mountain. That is what we will be discussing this morning.

The importance of this review takes on an added meaning because of the recent request from Chairman Selin to determine if the current research program of the NRC and its contractors is focused on meeting the regulatory decisions that must be made by the NRC and if there are any additional areas of research needed for this purpose -- the regulatory decisions that are currently not being addressed in the center or the NRC's Research and Technical Assistance Program.

We are all aware that DOE has had a decade-plus study of the volcanism issues at Yucca Mountain, and has made statements that indicate that they are rapidly approaching the point where they believe they can close out the issue of basaltic volcanism at Yucca Mountain. Their contractor reports indicate that they cannot predict the timing and precise location of future volcanic activity or events at Yucca Mountain, however, they can define the risk of future events through a three-fold conditional probability, considering the recurrence rate of volcanic events at the site, the probability of disruption of the high-level waste, and also, finally, the probability of volcanic-driven releases that may exceed the regulatory requirements.

NMSS has been investigating this as well.

Certainly, Research has been involved in this and, over the past few years, the Center has initiated a program of technical assistance and research on this problem.

This morning we are pleased to have representatives of these three elements, the Center, the Research and NMSS to discuss the objectives of the volcanism research and the Technical Assistance Program, as viewed by these different elements, the program plans and progress to date, the relationship of research to the technical assistance, to the DOE's volcanism program. We hope we will also hear from some of the Center on the evaluation of DOE's revised study plans related to volcanism and their recent draft summary report.

We look forward to these presentations and the ensuing discussion. As I say, these take on added importance as we consider DOE's desire to bring this issue to a close in a timely manner and also Chairman Selin's request for a relevancy check on research. With that as a preamble to our discussions this morning, I would like to turn it over to you, Keith. I think you are going to start. This is Keith McConnell, the Section Leader of Geology and Geophysics of NMSS.

I noted, Keith, that you had no time limit on your presentation. So, being a good geologist, I assume you will take all of the time you have been given.

MR. McCONNELL: No. I will help the Committee stay on time, hopefully, with their indulgence.

[Slide.]

MR. McCONNELL: Again, by way of introduction, my name is Keith McConnell, and I am the Section Leader for the Geology/Geophysics Section. My purpose here this morning is to do two things. One is to provide you with a status report on all of the Division of High-Level Waste activities in the topical area of igneous activity and, second, to provide an introduction and framework for what the Office of Research and the Center is doing, by way of showing you the integrating mechanism that we are using to link all tasks within NMSS and the Office of Research.

The approach I am going to take is to discuss two major topics. One is to discuss our reactive activities, and that includes our reviews of things like the SCP, the Site Characterization Plan, and also our study plan reviews. And then, second, I will get into the proactive activities, which include the Phase 2 IPA assessment that is currently coming to completion within the staff, and also then discuss the license application review plans that relate to igneous activity. It is these license application review plans that are the integrating mechanisms for the research activities. I would say that our efforts in LARP development -- and that is License Application Review Plan -- LARP Development --

are I think just beginning and it is not all completely integrated; but hopefully I can show you the flow-down of how we get from our compliance determination strategies, down through the identification of uncertainties, and then into user needs, which then are passed on to Research.

I do have to admit that I am a little bit apprehensive though because I think each one of these sub-topics here could be a presentation in itself. A lot of the material is pretty complex, and it is difficult to explain in one or two viewgraphs. So, if I lose you or I get into jargon, let me know and I will try to pull this back out.

Okay. Study plan reviews. Under this topic I have included our site characterization plan reviews. To this date we have 39 comments and questions that result from our site characterization plan reviews and our study plan reviews. 36 of these remain unresolved at this time.

MR. HINZE: Is that an unusually large percentage, in terms of the volcanism problem, in contrast to other areas, Keith?

MR. McCONNELL: I can only speak for perhaps a similar level of concern, and that is structural deformation. I would say that it is in the same order of magnitude as structural deformation, although the relationship is different. In other words, in the case of igneous activity, most of the comments were generated in the review of study plans. Whereas, with respect to structural deformation, I think we had most of our concerns expressed in the site characterization plan, and a proportionally fewer number in our review of study plans. So, it is not way out of whack with structural deformation, considering the level of concern. Now, with respect to erosion or some other concern which is a lower level concern with respect to the staff, it is significantly higher.

36 of the 39 comments remain unresolved at this time. We have resolved three comments and/or questions with DOE through interactions between ourselves. Just to kind of break them down a little bit. We have 22 comments. Three were generated in the site characterization plan review in 19 -- and study plans, two questions in the site characterization plan and 12 in study plan reviews. We have reviewed three study plans to date, including a couple of revs of the study plans, and we have one study plan that is in progress that we hope to have out in the next couple of months.

MR. FOLAND: Keith?

MR. McCONNELL: Yes?

MR. FOLAND: Could I ask you to give us an example of comments and questions that are remaining as open? Can you think of some examples?

MR. McCONNELL: Let me get to the next viewgraph, and I can expand a little bit more.

[Slide.]

MR. McCONNELL: One thing I will point out is John Trapp is here, and he has been the technical lead on most of these reviews. So, if we get into the details, I think I will pass it on to John. If I don't answer your question let me know.

MR. FOLAND: Okay.

MR. McCONNELL: One thing I did want to point out though is that the Center is not only doing research, but is heavily involved in all reviews of study plans at this stage. They actually -- their evaluations form a significant amount of the basis for our reviews. They provide us with the expertise in certain areas that the staff doesn't have. So, the scope and the content of our reviews is probably broadened by the expertise that they bring into the review process.

Now, what I have attempted to do is categorize the comments that are outstanding into five categories that also reflect our concerns with the volcanism topical status report which I will discuss in the next viewgraph. And these five major categories were described to DOE in a letter on August 18th. But, generally, they fall into five categories. The adequacy of plant testing, and this includes our concerns over the extent and likelihood of geophysical testing, and also gets down to lower levels of concern, such as the testing for the volatile content of magmas that have been erupted out at Yucca Mountain. I think Brit Hill may talk about that a little bit more in his presentation about the significance of those comments to the determination of the hazard.

Okay. We have 18 comments related to that -- comments and/or questions -- the use of the tripartite probability by DOE. This is their approach to determining the hazard. We raised concerns with the scope of that probability determination -- in other words, at the present time at least, to what we have seen, only addresses the direct hazard related to igneous activity -- that is volcanism or a dike erupting right through the repository. It does not address things like the indirect effects of volcanism, in other words, a near-miss, where you might have hydrothermal fluids that could affect canister lifetimes and things like that.

We have also raised the concern about what we feel are unsupported or poorly supported conclusions in the study plans. And an example of that would be the waxing versus waning relationship that the DOE appears to believe is most likely waning. I think the Center may address that later, I don't know. But there are I guess different opinions about whether things are waxing versus waning at this time.

The use of only homogenous poissonion models -- and I know that Chuck Connor will discuss this in some detail. At the present time, the DOE approach is to only look at homogenous poissonian models. I think it is clear from the Center's work that perhaps they ought to look at different approaches that are more realistic and involve the geologic process more. Right now all we have are statistical models that don't incorporate any of the geology. It is basically drawing a circle around the dots, where the volcanos existed at the surface.

Finally, there is the consideration of uncertainty, and that includes uncertainty related to the approach to looking at alternative conceptual models in the probability calculations, and also concerns at a lower level, such as the uncertainty and the age determinations of the basalts at Yucca Mountain. Apparently the uncertainty and the age determinations roll up into uncertainty in the recurrence interval, which then lead to uncertainty in the probability calculations. All of these things I don't think we believe have been brought out or have been looked at in sufficient detail for the DOE to come in and say that they are able to resolve the issue of volcanism at this time.

MR. HINZE: Keith, before you leave that transparency, the majority of these really date back to the SEA, as I understand it. That is four years ago. What efforts have been underway to resolve these? Has the fact that they are resolved the fact simply a matter of the NRC not responding in a positive way to the DOE's response to your comments and questions? Has there been communication that has led to a negative response?

MR. McCONNELL: I am not sure about the tone of the response. I think that -- and we have experienced this in other topical areas. I think that in a lot of cases we end up not talking to each other, but talking by each other. And it becomes very difficult when you are not listening to resolve issues. Also, it is very difficult I think in the environment we work in to actually sit down and resolve issues. It basically boils down into kind of badminton letters, where we are sending each other letters. We do have technical meetings, but they become very formal and they basically are formal presentations. So, the mechanism for resolving these is very difficult.

MR. HINZE: It doesn't lead to a lot of give and take type of situation?

MR. McCONNELL: I think that is what is necessary. I don't know that that has occurred at this stage.

MR. HINZE: The important point though is that the DOE has been responsive to your concerns and questions, but simply that you have not accepted them.

MR. McCONNELL: That's correct.

MR. HINZE: You are an open item. So, you have not accepted them, and there has been a negative response.

MR. McCONNELL: Right.

MR. HINZE: Is there any effort for DOE to become involved in or to visit the Center for Research and see what is going on on a first-hand basis that might be a better chance? Is that possible within the mechanism between DOE and NRC?

MR. McCONNELL: I think it is possible. I don't know that it has been suggested or asked for. The approach we have taken in the past is for the Center representatives, Chuck Connor and Brit Hill, to make presentations of their work at focus meetings and the International High-Level Waste Conference and meetings like this, so that DOE and others can get an idea of where the Center is coming from. I think -- I hate to cast it as all negative -- I think that, in my view, there has been movement, it is just that -- and I heard it described I think at the focus meeting as two people violently agreeing on issues. So, I am not sure how far apart we are, but there certainly seems to be a lack of an ability to resolve questions and comments.

MR. POMEROY: Keith, just to follow that up a little bit. It was my understanding that these comments in the Holonich to Shelor letter were partially based on the SEA, partially based on the study plans and partially based on the LANL technical report on volcanism. Can you tell us what the staff is going to do with the technical report on volcanism? Is that part of your presentation this morning?

MR. McCONNELL: I will discuss that briefly. The staff, at this time, is not going to do anything further with the status report. It was a draft when we received it. It was a draft contractor report, and it was cast in those terms. It was not a DOE-adopted report at that time. Therefore, our review is limited. We did not create staff open items related to that because it was a draft report. What we did do was just provide DOE with areas of major concern. It is up to DOE to decide whether they would make it into a topical report where they actually would come into the staff and ask for a formal review and a formal safety evaluation of that aspect of the geology of the site. At this time, we don't intend to do anything further.

Now, there is I guess an indication that DOE may or that Los Alamos may finalize that report and issue it, and DOE may ask us to follow-up with our concerns, and I assume management would entertain another review.

MR. POMEROY: Thank you.

MR. STEINDLER: Do you file or make a comment, as you have got them up there and divided into these five categories -- is it practice to explain in some detail why a particular comment is relevant to some larger goal?

MR. McCONNELL: In general, the baseline for deciding whether there is a comment or a question is that it is a significant factor in the analysis of the hazard. That is based on the review plan for -- it started with the site characterization plan review plan in which the definition of objective comment and question was laid out. And our indications there that it has to be a significant concern with determining the hazard which then would be a significant concern to the repository in order to make the cut into a question, comment or objection. Of course, the level of significance to the repository is where it would be placed in that question, comment and objection.

MR. STEINDLER: No, I understand that. The question I have is whether or not that -- the internal determination within the staff is transmitted in fairly clear terms to the Department, together with the actual content of the question or the comment?

MR. McCONNELL: In general, no. It is believed that --

MR. STEINDLER: They kind of have to guess as to why you think it is important?

MR. TRAPP: Is this one on?

MR. STEINDLER: Yes, it is on.

MR. TRAPP: Each one of these comments -- John Trapp -- each one of these comments basically is a four-part write-up. There is the original comment which is kind of a summary of the concern. Following the comment, there is a listing of bases. Now, these bases may be technical reasons why we have got concerns, they may be regulatory reasons. But, we try in the basis to lay out specifically the things that you are talking about -- why have we got the concern, where it falls into the overall picture.

Following this there is a recommendation of some type of action which we would suggest that DOE take to resolve this comment, and that is followed by a whole listing of references which will back up this thing. So, yes, your concern I believe that we are transmitting why we are concern -- we attempt our best. Sometimes, no, we don't get there, but we definitely do try.

MR. STEINDLER: Okay. Thank you.

MR. McCONNELL: Okay. We have mentioned it briefly. We did receive the Los Alamos National Lab's Volcanism Status Report, and that is the shorthand term for it. Assisted by the Center, we have completed our review, in a preliminary form, in May of '93. We had an NRC/DOE technical exchange where both the staff and the Center provided their comments. Again, the Center comments, at this stage, were Center comments. They were not adopted by the staff.

We then sent, after the technical exchange, we sent DOE a letter noting the five major areas of concern and, again, they are -- these five areas of concern were the ones that I categorized these site characterization plan and study plan comments in. And then, in November of '93, DOE responded to the five major areas of concern; however, the staff feels that the response is insufficient to resolve the concerns at this time.

MR. HINZE: Keith, can I ask a question there regarding the Center's comments without being the staff's comments?

MR. McCONNELL: Yes.

MR. HINZE: What does that mean?

MR. McCONNELL: The Center produced --

MR. HINZE: What are the implications of that? How do I take that if I am a member of the DOE staff?

MR. McCONNELL: The Center provides us with an independent product. It has been a staff judgment to decide which of those comments and questions that they develop are applicable to what we think are important repository considerations. Because this was a draft DOE status report and a draft Los Alamos report, and not a DOE report, we felt it was inappropriate to generate staff open items related to that report; therefore, what we did was we used the Center's input, their comments and questions and other observations they made in their review, as a basis for coming up with these five general areas of concern. So, we used the report, but we did not adopt them as staff open items. I don't know whether that is clear or not, but -- it is input.

MR. HINZE: I think it helps. But, let me ask does the staff review the Center's comments before the Center is permitted to make those comments, and thus de facto, puts their imprimatur on it?

MR. McCONNELL: I think we had discussions throughout the review process -- discussions and meetings where we actually went over the concerns that the Center was generating. So, we were aware of the concerns. The final product -- we reviewed that and we provided the Center with comments on that final document before it was finalized. And the final document did include the staff's input.

MR. HINZE: And the staff's input is largely from he regulatory basis of these concerns, or is this also from the scientific concerns?

MR. McCONNELL: I would say it is all of other above. It was technical, regulatory and bureaucratic.

[Laughter.]

MR. HINZE: How do you spell that last word?

[Laughter.]

MR. POMEROY: Let me follow up just a little bit on that, Keith. It seems to me that this could quickly lead to a gridlock situation. The DOE transmits a draft contractor report to you which you say we are not going to review any further since it is a draft document. You send comments back to them that are essentially staff-reviewed Center comments but not adopted by the staff. Very soon you have them saying well, what do we do with those? Do we simply ignore those? It seems to me, you get to the point where you are not talking in a very effective manner. Is that in effect what is happening here?

MR. McCONNELL: I think you may be correct. Again, it is very difficult in this process to reach resolution or even to communicate. What we said in the letter to DOE was that the Center's comments would form the basis for any further review that we conducted of either a rev one or the final status report or a topical report on igneous activity. So, we gave them an indication that we did agree with the Center's comments by and far, and that they would then be a significant component of our review of any further documents. So, I think we did provide them with some guidance. But, again, it is difficult for us when we get in a report that is not a DOE-sanctioned document. I think, if you remember back to the site-suitability analysis, it was a similar difficult situation.

MR. POMEROY: It is extremely difficult.

MR. McCONNELL: Yes.

MR. FOLAND: Keith, one more thing. Could you amplify on your last bullet there, and that is concerns are unresolved. How would you qualitatively characterize the degree of resolution? Has there been some movement toward common agreement on some items? Some items have been resolved, others are unresolved. Has anything changed?

MR. TRAPP: John Trapp again. In some cases there has been resolution. In certain cases I would say absolutely no. It basically covers the entire spectrum. Now, for example, some of those concerns remain totally open and deal with the whole geophysics testing program. Now, the last time this thing came up there was a basic statement by DOE that if you take a look at study plan X, Y, Z, et cetera, all of the information will be there. However, this was followed by a statement that they really hadn't reviewed what the program was so they would have to tell us later exactly what they were going to do. I don't consider this a resolution. We have had a series on this tripartite, which may seem like a small effort. But, basically, what it amounts to is it is a method of trying to solve the concern without understanding the regulatory basis of the concern and giving an answer which does not reflect what is needed for basically answering the regulations.

Now, if you continue on this one -- this one has been in total deadlock. It keeps on coming back and nothing happens. Yes, some have been resolved; but, take your pick, we -- I would say that really we are seeing about a 10 percent resolution right now.

MR. McCONNELL: In the DOE responses there are good intentions. I think we have made a decision within the staff that we can't resolve issues on good intentions -- that we will wait till those intentions come to fruition and then we will make a decision on whether the open item is closed.

MR. POMEROY: Well, is it your contention, for example, in the tripartite probability use, that that simply doesn't allow you to consider the uncertainty bounds in this particular subject? It seems to me that one could reach some conclusion on the boundaries of the uncertainties, even perhaps without doing everything in the field. And that -- is there a problem with -- can you see a problem that ultimately leads to DOE's not considering the full range of uncertainties in the problem?

MR. McCONNELL: Well, they have indicated that they will. The documents that we have to date have not expressed that in terms that we would agree with -- that analysis that they are doing it now. I think we are somewhat concerned that they appear to be only looking at one approach. And we would recommend and we have recommended that they consider alternative approaches, particularly when there is this much uncertainty with the technical aspects and this much concern with the consequences of the event occurring. So, what the staff is trying to communicate is that alternatives are good. Look at alternatives, analyze them and the effect they might have on the probability calculations as well as the consequence calculations and then come up with a preferred model. Don't provide us with a preferred model or preferred approach and not look at these alternatives. Because what happens is we have other people, very knowledgeable people that come up with the alternatives and there is variation within the numbers, and there is concern about incorporating geologic processes into the hazard calculations. These are expressed at the Center and they are expressed by the State of Nevada. So, we are looking for a broader analysis of the hazard and then coming up with the preferred model. I think we have tried to express that.

MR. HINZE: In view of this snail's pace of progress that seems to be being made on these items, does this lead NRC to doing DOE's job? How far do you go to show DOE that there are alternatives and that there are different approaches and that adequate data will provide critical information? How -- you must, in providing these comments, support that with information. How much of that are you doing that really is a matter of DOE not doing their job, in your view?

MR. McCONNELL: Well, we tested in terms of developing our own independent review capability.

MR. HINZE: I realize that. But that doesn't answer my question.

MR. McCONNELL: I think that we are very sensitive to the criticism of doing DOE's job for them. We try to limit our activities. When I get into the development of review plans that is part of the mechanism where we try to limit what we do to only those issues that require an independent review capability. In other words, an ability not only to be knowledgeable and ask the right questions and to know the right answers when we get them, but also an ability to develop alternative approaches that we can suggest to DOE that they might try that might have a significant effect on the calculations.

We don't think we are doing DOE's job for them. If there is a significant problem, and we think DOE should be doing different, we tell them so, and we have told them so in a number of the comments and questions that we have generated. We don't reproduce that activity at the Center.

MR. GARRICK: As a follow-up to Bill's question and in connection with your second bullet, is it your opinion that the interaction between NRC and DOE, aside from the formal meetings, is at about the pace it should be?

MR. McCONNELL: Well, the pace is established by

DOE. It is up to them to decide what the pace is.

MR. GARRICK: One of the criticisms that I have heard frequently with regard to the interaction with EPA for example is the lack of communication between the two agencies on standards requirements and regulatory requirements. I was curious if the log jam that we are concerned about could in any way be lessened if the communication process was changed somewhat?

MR. McCONNELL: I think, if there were alternative mechanisms for communication, it might improve the situation. In earlier years, back in the late '80s, we used to have appendix 7 visits, where we could actually just talk to the technical folks. And I think the level of discussion was more compatible with I think coming to resolution between the technical folks, and then it doesn't get raised to a higher level -- the disagreements.

Subsequent to that we have found that the interest in the program generally turns appendix 7's and technical exchanges into rather large meetings. You know, 30 people at a technical exchange is not uncommon. That I think has an adverse effect on communication. Appendix 7's are coming back -- Appendix 7-type meetings are coming back, and they are in the procedural agreement.

MR. GARRICK: It sounds like what you are saying is that the optimum lies somewhere between where we are now and where we were with Appendix 7?

MR. McCONNELL: Yes. That would be my view.

MR. STEINDLER: Allow me to quote two items out of the Holonich Letter. And let me suggest to you that at least somebody reading this might view this as an unreasonable approach. On the tripartite issue you indicate that you are not satisfied with what they are doing because not all the effects of volcanism are considered. In the uncertainty analysis item, there is an interesting segment that says failure to test and evaluate viable models because they may appear overly conservative is unwarranted. Now, I am taking everything out of context, so I understand that. Both of those are I guess what I would call limit drivers. You are calling for consideration of all -- you didn't say some, you didn't say some important, you said all effects of volcanism -- indirect effects, and then in the other area you are suggesting that it is not reasonable for the Department to evaluate to the level of conservatism of a model before it decides whether or not it should be even considered further. Is that really what you mean to have the department do and, if so, why do you drive them to that level? Am I misreading it?

MR. McCONNELL: No. I think you are reading it correctly. I think the intent may be different. With respect to the tripartite probability, again, it boils down to whether you can resolve the issue of igneous activity. Now, there are various subparts to that issue -- one is direct disruption of the site. Now, the way to approach it would be to send us a report that says we are only going to address the direct disruption of the site in this report. Okay. In that case, that is all we would expect to see, and we would not comment on it. We might not have a problem with the tripartite probability under those circumstances. But, when the report is casted at resolving the issue of -- or saying enough is enough about igneous activity in total, then there are all of these other aspects like near misses -- the effect on groundwater flow that also have to come into the calculations of the probabilities and the calculations of the consequences. So, that is the reasoning behind the total -- the concern with the tripartite probability. It is not necessarily that we are driving them, it is how it was presented to us.

Second, with respect to the consideration of alternatives, we think that again -- and this concern has gone back to our review of the site characterization plan -- that there has been at least an appearance that there is an attempt to prove a preferred model rather than looking at alternatives and testing alternatives during the site characterization phase. What we are suggesting to DOE is to at least recognize that these alternatives exist and then address them and give us a range -- and they have to a certain extent -- a range of probabilities for those alternatives. And they have indicated to us that they will -- they believe they are doing it and they are going to try to clarify it in any future approach. If they do that, then I think the comment may go away or the concern may go away.

MR. STEINDLER: Well, I will just make a comment that your explanation is much different than what I read into this letter. My reading, being infinitely ignorant on volcanism in general and certainly on the specific model topics was that this is a very hard-nosed letter that says if you guys don't consider everything under the sun, regardless of how conservative the models are, you are not doing what we have asked and we are not going to give. That is what I read out of this thing. I thought well, gee, if that is the basis of the gridlock, then maybe that gridlock is a binary rather than a single source problem.

MR. McCONNELL: We try to be flexible.

MR. STEINDLER: Okay. Thank you.

MR. McCONNELL: But, I think you have pointed out the problem of again trying to communicate via letter. When you bring into the equation the economy of words, and other factors in the generation of a letter, things don't get across sometimes -- the ideas don't come across as they are intended. That is why we again try to communicate informally.

Okay. Now, to get into the proactive areas of staff activities, I will very briefly discuss the IPA Phase 2 iterative performance assessment effort that has been ongoing with the staff. Basically Phase 2 considered the topic of igneous activity, the purpose, with respect to igneous activity as it was with the entire effort, was to develop the assessment capability -- in this case to evaluate igneous activity in terms of total system performance. The effort was considered a first step. It was based on what we considered limited site data and used numerous simplifying assumptions regarding probability and consequence.

I would say that, in the planning for IPA Phase 3, which is the next iteration, I believe volcanism will be included in that. I think there will be some maturing of the assumptions regarding probability and consequence in that.

MR. HINZE: Will there be any effect of groundwater alteration in that?

MR. McCONNELL: I don't believe so. This was, again, just considering direct disruption of the site.

The results of Phase 2 showed that the contribution to the CCDF are low probability and high-consequence. I don't believe that is necessarily a surprise considering the knowledge we have about igneous activity.

There were increases in normalized release, 15 times above the EPA limit with direct release from volcanic cones. And the contribution to the release in liquid or gaseous pathway with dikes intersection canisters was considered insignificant. I believe the staff is going to brief the ACNW on this in the next couple of months.

MR. POMEROY: That's correct, probably in May, Keith. Just for the record, when you say they are low-probability, high-consequence events, what do you mean by low-probability?

MR. McCONNELL: We are talking down in the range of 10 to the minus 8 I think was the value used in the IPA Phase 2, if I am not mistaken. Do you remember?

MR. POMEROY: For a year?

MR. McCONNELL: For a year. Yes, an annual probability.

MR. POMEROY: Right.

MR. HINZE: Keith, I don't want to plow old ground, but let me ask a very quick question. Who is responsible for putting into the IPA the results that are coming out of Research and also the interpretation of the DOE data? Is that your group?

MR. McCONNELL: That is our group.

MR. HINZE: How do you do that? Can you give us a little bit of a picture of how that is carried out --

MR. McCONNELL: It is kind of a parallel path.

MR. HINZE: -- in terms of particularly research?

MR. McCONNELL: Yes. Research work, the work that Chuck and Brit are doing is inputted to IPA through the performance assessment program manager down at the Center, Bob Bacca, with Larry McKague, who is the geologic setting elements program manager's concurrence. So, the input at the Center goes basically from the geological setting people, through Larry McKague to Bob Bacca, who are the performance assessment folks. It is not all that bureaucratic, but that is the formal mechanism.

MR. CONNOR: Keith, I would like to make a comment about them. My name is Chuck Connor. In the past that link between the PA models and the research models has been a little bit tenuous, but we are working hard to improve that by specifically developing some PA sub-tasks which deal specifically with incorporating results for volcanism research into the current PA models for Phase 3. In fact, much of our research program is really designed to provide some rapid input into IPA Phase 3 through those programs. For instance, we are working to develop this linkage between hydrologic processes and volcanism, which wasn't in PA Phase 2, but we planned to put that into Phase 3 through one of these sub-tasks in the IPA group. So, the process is becoming a little bit more streamlined at the research level. So, for instance, Brit and I interact with Randy Montoifle now, a PA scientist at the center and there is a little bit of a direct feed in there. In fact, we have been able lately to just go ahead and take out for instance the volcano module in IPA Phase 2 and make modifications to that to better reflect our current research efforts. That process is going to be smoother in the future through those efforts to develop those sub-tasks.

MR. HINZE: Great. Perhaps you could give us a little more concrete illustration when you make your presentation.

MR. CONNOR: Yes.

MR. GARRICK: I just want to make one quick follow-up comment on that. Bill is talking about the flow of information from Research into Performance Assessment. I think most of us would agree, if a performance assessment is working right and in place, there should also be some clear guidance to research precipitated by the performance assessment activities. As a matter of fact, it should be one of the principal illuminators of what research is being done. Marty, if I am asking questions that are out of line given that I am a new member, you can bring me back on course I am sure.

MR. CONNOR: This is Chuck Connor again. I agree with that completely. That is why the first slide in my talk is the PA model which drives their volcanism research. I will be talking about that more in my talk.

MR. GARRICK: Good.

MR. HINZE: But, if I understand correctly, the NMSS staff is out of the loop then?

MR. McCONNELL: No, that is not correct. We are involved ourselves. It is basically a team effort. There are section members that are involved. We communicate with Larry McKague about what is going on. We are involved in reviews of any of these sub-tasks that Chuck would submit to Bob Bacca or the PA group. So, it appears bureaucratic, but we are involved and we try to make it a team effort. I think that we all agree that it could be improved and we are working to do that.

MR. HINZE: Okay. Thank you.

MR. McCONNELL: I would like to move on now and talk about license application review plans. The discussion here is assuming that you have some knowledge of the systematic regulatory analysis or SRA process. Just to kind of briefly go over it, basically, what the staff does is it develops a compliance determination strategy, a CDS, for the various regulatory requirement topics. It then identifies key technical uncertainties with respect to that regulatory requirement topic. In this case it would be the presence of igneous activity. It then, if the process is working, would develop user needs statements to address those key technical uncertainties, and then that would then be forwarded on to Research as a desire to create research, if it is needed, to address those key technical uncertainties.

And this is the flow-down that is supposed to occur in the LARP, or licenses application review plan's process, again, where you would develop a compliance determination strategy, identify in that process the key technical uncertainties. And key technical uncertainties are those uncertainties that do have a risk of affecting performance, and they are types 4 and 5, depending on whether we need independent modeling ourselves or not. Type 4, basically we would use DOE's models. A type 5 review would require our own independent modeling capability. From that then we would develop user need statements about the type of information we would need in the form of research, perhaps GIS, geographic information activities or actual modeling capabilities, like Chuck is doing at the Center on volcanism. So, it feeds down.

Now, that is the way it is supposed to work. Unfortunately, with respect to igneous activity, we had established user needs a while back, before the SRA process really got going, so we have these use needs and until we identify all of the key technical uncertainties we don't intend to revise these, so the user needs are not a one-to-one relationship to this potentially adverse condition, but they eventually will be.

I hope I haven't lost people.

Now, review plans for license application review plan are, again, just starting. The evidence of quaternary igneous activity and the projection of that activity -- in other words, the calculation of the hazard, will be components of a number of review plans, many of them not completely in existence, although the LARP rev zero will be coming out in the next view months. There is still a lot of work to be done.

Igneous activity will probably be a component of system description -- many of the PAC and FAC review plans that require input on igneous activity and also design and performance review plan. When we finalize these there will probably be additional key technical uncertainties -- and I say additional because we already have three identified -- that will be developed under these other review plans. Many of these uncertainties may require research or independent modeling capability.

Now, what I would like to do now is go to the one --

MR. POMEROY: Keith, before you leave that, let me just ask you I think we all understand something about key technical uncertainties anyway. You say many of these uncertainties may require the development of independent review capabilities. One of the things I am trying to sit here thinking about in my mind is all right, let's identify those key technical uncertainties. It there is an independent review capability needed, then perhaps it is an legitimate NRC function to do that. Where there isn't key technical and where there are key technical uncertainties that don't require that independent review capability, and I gather -- that is what I imply from the many there, but not all apparently -- are there other uncertainties, ones that we just simply convey to DOE, or do we not convey them to DOE? Do we -- what do we do with those? I mean, is everything that we are doing ultimately in research related to resolution of a key technical uncertainty so that we have an independent review capability in other words?

MR. McCONNELL: Yes.

MR. POMEROY: Okay.

MR. McCONNELL: The one distinction I would make is that the staff -- and I am sure you have probably heard this before -- doesn't resolve the uncertainties, it is DOE that resolves them. All we are developing with this process is the ability to review what DOE's resolution of the key technical uncertainties.

Basically, type 4's generally would not require -

- the uncertainty is not as great and they would not require the development of independent modeling capability. But, they are of such significance that they do require a detailed safety review. The emphasis is on what has been identified as type 5 reviews, where the uncertainty is so great or the risk to performance is so great that it does require our own independent modeling capability. Okay.

Now, again, I would just like to run you through perhaps the most complete review plan that we have. That again relate to the potentially adverse condition evidence of quaternary igneous activity. It is a literal identification. In other words, the only thing we are addressing with this review plan is evidence of igneous activity in the quaternary. We are not addressing the probability or consequences of igneous activity in the future. It is only whether you found it and how much there is out there. So, the key technical uncertainties and eventually the user needs would only address that one very narrow issue. The probability calculations would be in other -- or the review plans for probability calculations would be in other review plans, if I didn't just repeat myself.

We have identified three key technical uncertainties with respect to the potentially adverse condition. One is the fact that there is out in that area poor resolution of exploration techniques to detect and evaluate igneous features. That was classed as a type 4 review. There is an inability to sample igneous feature out there because they are not exposed at the surface obviously. That was considered to be a type 5 because the uncertainty is higher.

And then finally the development and use of alternative tectonic models as related to igneous activity. Again, the consideration of alternatives was also classed as a type 5 review.

MR. HINZE: Is another word for uncertainties deficiencies? Is that a deficiency in their study plans?

MR. McCONNELL: No. No. A key technical uncertainty is an uncertainty that has a high potential risk to noncompliance with a performance objective. In other words, there is a key technical uncertainty, or there is a technical uncertainty and it is key because it has a high potential risk to a performance objective. These are all related to a performance objective or to multiple performance objectives. So, there is not a deficiency. These only refer to the level of review and the emphasis the staff will place on the review. In other words, there are type 3 reviews which are safety reviews, but basically are not going to require any independent modeling, only back of the envelope type calculations. They will require no research at the Center. There will be no user needs for those reviews. We believe we have the modeling -- or the capability at this time to review those uncertainties. So, these really do refer to air bars -- that these uncertainties will lead to large air bars and items that have considerable adverse effects -- may have considerable adverse effects.

MR. McCONNELL: The potential for considerable adverse effects.

MR. HINZE: Thank you.

MR. POMEROY: Keith, going back to your second bullet for just a minute. I am still back there.

MR. McCONNELL: Okay.

MR. POMEROY: You don't address probability of igneous activity in the future or consequences of an even under this particular -- there are too many activities here -- under this particular activity, namely the quaternary igneous activity portion of the license application review plan? I presume that those will be addressed under the license application review plan. But, are there other activities within the review plan? Is that what you are saying?

MR. McCONNELL: Yes. You are correct.

MR. POMEROY: Okay.

MR. McCONNELL: Okay. Now to talk about the user needs that are in existence at this point. Again, these were user needs that were developed prior to the identification of the KTUs. This is the case across the board in all disciplines. We developed the user needs I would say maybe three or four years ago. And it is only in the last couple of years that we have started in identifying the KTUs. So, again, there is not this nice mesh or integration that you would like, but we have just got to catch up with the process.

Again, the user needs -- they address the presence of quaternary igneous activity, but the user needs now, since they are broader, also address the likelihood of future events and possible consequences. So, the review plan we now have in place for the evidence of quaternary activity does not address those, but the user needs do. Again, they address the broader issue than the KTUs that we have got identified to this date and, again, they will be modified when we finally reach the conclusion of the review plans.

Just to identify the use needs that we have in place, with respect to igneous activity. These are them. Evaluation and mechanisms of processes that control the location of igneous features; evaluation of past temporal and spatial patterns of igneous activity and the evaluation of the effects of the igneous activity on groundwater flow;

the evaluation of multiple theories -- or theories of multiple volcanic eruptions, and the evaluation of age determination techniques. These user needs were used to establish the work plans at the Office of Research, with the Center developed and that the Center is trying to address with their plan of research. So, this is the introduction to what research is doing. So, we have got the CDS, we have got the key technical uncertainties, which are related to performance, we then identify user needs, goes to research, and then we develop the research plans with the Center to address those user needs. So, it is all linked, and it is linked to performance.

MR. POMEROY: When we get to the research presentation, I would like to hear a statement with regard to how many of these particular user needs for example the evaluation of mechanisms and processes that control the location of igneous events -- how many of those will be resolved in a manner -- in a time frame that is going to be useful for the current time frame that exists for the repository. That is a question for later, Keith, not now.

MR. McCONNELL: Okay.

[Slide.]

MR. McCONNELL: And then my last viewgraph is just the one I showed previously. It relates the specific user needs to the key technical uncertainties.

The type 4 review, because the user needs are fairly broad, we believe we can get some input into this type 4 review by the two use needs, 601 and 605 which are evaluations of mechanisms that control and the evaluation of age dating techniques in volcanic terrains.

It was decided in the development of the review plan that there was very little that could be done with respect to the inability to sample igneous features at depth, so no user needs relate to that activity. And then the use of tectonic models. Again, it was believed that the research ongoing at the center would provide input into the review of the use of alternative tectonic models for igneous activity. The one user need that is not tied directly to a KTU at this point is the effects on groundwater flow, and that is because we haven't identified that key technical uncertainty yet. That is still in the process of development of the license application review plan for those other potentially adverse conditions. There is a potentially adverse condition that says the effect of natural phenomena on groundwater flow I believe, or something like that.

MR. POMEROY: In the one place where you have no user needs established -- that is the occurrence or whatever of igneous activity at depth, isn't that one of the keys to the whole question of igneous activity? Is it because --

what is the rationale behind saying well, we don't have any need for that information basically?

MR. McCONNELL: Well, we do have a need for that information. We didn't believe we could address the uncertainty through research. We believe that -- maybe I could let John speak to this, but there is some uncertainty that we are going to have to live with and this may be one of them, and we will have to approach the review from a different perspective.

MR. POMEROY: What is that perspective?

MR. McCONNELL: John, you wrote the CDS.

MR. POMEROY: Nicely done.

MR. TRAPP: I didn't write that slide.

[Laughter.]

MR. TRAPP: One of the points I think that needs to be brought out really is the fact that this whole process is ongoing, along with the research need identification and this type of thing. At the present time, no, we don't have a direct user need there, but we do see the possibility that user needs will need to be put in this area. We are presently exploring more in the area of taking a look at what can we do with the conceptual models, what can we do with the things like the exploration techniques, et cetera, to narrow these things down, and then possibly broadening this area. Does that help at all?

MR. POMEROY: That certainly helps partially. I guess I am still wondering how you determine it. One thing you can say is well, among other things, there is a user need there. We can't clearly find it at this point in time, and so we will at least identify it in the sense of it being a problem and certainly DOE has to.

MR. TRAPP: We have identified it as a problem.

MR. POMEROY: But DOE will certainly have to address it in the course of --

MR. TRAPP: It has been identified as a problem and a problem that has to be addressed when we get through reviewing the license. What we haven't done is come up with a good specific way of resolving the concern yet. And because we haven't come up with a way that we can really resolve the concern, we haven't been able to carry it into a good statement of a user need -- a specific statement -- to tell Research, look, we need this or this done. We have got a bunch of activities which probably can relate to this. The problem is the specific user need has not been written.

MR. McCONNELL: In the process we could potentially identify a user need and just say TBD or something like that on how to approach it. Maybe that is a better way of approaching things rather than just leaving it at the issue stage or the concern stage.

MR. POMEROY: I am wondering in all of these cases what is the division line between what DOE should be doing and what the NRC research staff should be doing.

MR. McCONNELL: Well, again, I --

MR. POMEROY: Apparently you have decided that, at least in these five areas, 601 through 605, that we should resolve these issues. Is that an appropriate division of labor in your estimation?

MR. McCONNELL: Well, again, let me just draw the distinction. We don't resolve the issue, and I think that is a key distinction, because DOE does the research to resolve the review. Our research is only focused on improving our ability to review what DOE provides us. So, it is kind of a three-fold input that management uses to make a decision on what research is used. One is -- and I am repeating myself to a certain extent -- that we have to be knowledgeable enough -- in other words, we have got to do enough work to where we can ask the right questions and evaluate whatever DOE provides us in the area of igneous activity. Second, there are areas of concern, like high consequence events, igneous activity being one, or high-probability events, high-consequence events, that we can't rely solely on what DOE provides us. This is a case with respect to igneous activity that we feel that we have to, because of its high consequence and also its high profile, that we need to develop our own independent capability to approach volcanism or igneous activity. I think it has shown benefit. I think we have been able to provide guidance to DOE to look at alternatives -- the nonhomogenous poissonian models being an example.

Finally, I think a third input is the results of our reviews. If we believe the DOE is taking the correct approach, and we don't need to develop an independent review capability, but DOE just isn't far enough along the path, then maybe we might have a type 5 review, but we would withhold performing any research to develop our own independent capability. I think our interactions and the number of open items that we have on igneous activity suggest that there are differences of opinion between the staff and the DOE on the approach and we therefore think it is in our best interest to continue to develop our own independent modeling capability at this time. I think, if things change, maybe we would reassess that. I hope that --

MR. POMEROY: Okay. Thank you. Yes.

MR. FOLAND: It is not entirely clear to me how one -- how these user needs are identified. Who makes the choice? Let me just give you an example, to follow up on Dr. Pomeroy's question about what is at-depth. You have user need 605 as the evaluation of age determination techniques. Why not 606, which is the evaluation of geophysical techniques, to tell us what is in the subsurface? I mean, how are those decisions reached, and how are things prioritized?

MR. McCONNELL: Again, these were established a long time ago, so it is hard to defend the scope. The decisions, again, at the time that the user needs were established, was based on our knowledge of the site at that time, three or four years ago -- where did we think the major areas of concern were. We are now at a point where we are trying to fit those existing user needs to the key technical uncertainties that have been identified. Okay. That doesn't mean that we perhaps shouldn't do more in this area. In fact, the Center has -- is evaluating some geophysical techniques as far as their level of detection. But, we would say that that would probably fall into input here. So, I am probably not being clear, but it is difficult because we haven't established use of the needs that don't tie directly. But, the process, as it is designed to work, as we would identify these, and then there would be a direct one-to-one relationship to the use needs on how to address that uncertainty. That would be -- the approach to resolving that uncertainty would then be placed in research in the Center's hands to come up with the mechanism to address that uncertainty -- what is needed to address that uncertainty. Basically, the NMSS staff just identifies the uncertainty and identifies the user need. Did I answer your question?

MR. FOLAND: I think so. Let me ask it again more directly.

[Laughter.]

MR. FOLAND: Specifically, where do these user needs come from and are do new ones come up to the front and how are they then incorporated?

MR. McCONNELL: Okay.

MR. FOLAND: I mean, as you say, some things were formulated many years ago when there was a different conception of the geology of what the site was. And how does one then continue to modify user needs? Some arise and some then get eliminated presumably.

MR. McCONNELL: Yes. What would happen is we would get to the user needs status and we would probably get together. We have a tectonics and volcanism program review annually between the NMSS staff, the Office of Research and the Center, where all of the principals get together and talk, and they talk in terms of key technical uncertainties and user needs. We then identify those areas where we don't have user needs. This provides the Center and the Office of Research the opportunity to input into this process. They may be aware of key technical uncertainties that we haven't identified. They may also be aware of user needs that either have been resolved or need to be added. And it would be in this program review where all of this would be discussed, and then we would then go to management and say hey, we have got more user needs that we need to identify based on our discussions with the technical people, or we have additional KTUs, or perhaps we have closed out the need for that user need or that key technical uncertainty. Perhaps something DOE has done has addressed the type 5 review that is necessary and it can be down-graded.

The LARP, the License Application Review Plan, is going to be I believe published on an annual basis. I believe that is correct. So, there will be revisions annually. So, you will see things like this come and go, based on what we see from DOE and site characterization.

MR. TRAPP: Let me try muddying the waters just a little bit more too.

What you are seeing here is one portion of the LARP, only one little chapter, and it doesn't include, as it has already stated, those portions of the LARP, the CDS's, CDMs, all of those buzzwords, et cetera, which deal with projections, et cetera. Most of the projections, when you are talking about igneous activity would have to fall under the broad category of overall system performance -- in other words, resolving the EPA standard. Now, if you want to try to give an example -- for instance, one of these uncertainties which has been identified in the overall system performance is the uncertainty that is basically propagated due to uncertainty in parametric values. Carry that through to some of the things that we are doing -- one of the uncertainties that we have got right here is the uncertainty in age dating. We can talk about the uncertainty in age dating in a very broad thing, but then exactly what does this uncertainty do when we start projecting this forward? It is not covered under this CDS or under this portion of the LARP, it will be covered under the EPA standard portion. And there is work being done along this line not only on basically age dating techniques -- but one of the things, if you take a look at that report that is sitting out there that was done by Connor and Hill, there is a discussion of the real effect that this parametric uncertainty has on the total range in projections of probabilities. So, you are looking, like I said, at a very very small snapshot of the whole thing, and unfortunately, this CDS is the first one that has basically been written. The others are getting out there, but this one I guess -- yesterday I was told I was going to be made an example of -- that's the way this whole thing is going on right now. There are a lot of mistakes that are being made. It is not going as smooth as we would like, but we are trying to get there and draw these all together.

MR. McCONNELL: I think everybody agrees that the development of a LARP is an evolutionary process. Particularly when you consider that they were trying to systematically analyze a rule that wasn't systematically developed. So, we have to be careful and not leave gaps or have too much repetition. There is a balancing act going on within the staff to make sure that doesn't occur. That is why they have committed to do it on an annual basis, so that when we get more integrated and we perhaps have, as John says, have roll-ups, where we have key technical uncertainties that not only affect this potentially adverse condition, b other review plans -- relate to other review plans -- that we don't have duplication of effort, duplication of user needs and things like that. So, as John indicated, you are looking at the very lowest level of the review at this stage -- of the review plan. I know it is not completely clear.

MR. POMEROY: Let me just make one additional comment. Is somebody looking at the potential effects -- John brought up the question of age dating, and that is probably the hardest piece of evidence that we have got in many of these -- would you expect that to have eight orders of magnitude effect on final probabilities? That is, would you expect the 10 to the minus eighth probability to go to one? What -- does somebody -- I am not asking for numbers.

What I am asking is is somebody looking at the potential importance of determining it? I don't much care if it is a factor of 10 variation, as long as that factor of 10 variation doesn't multiply another factor of a thousand variation -- it doesn't multiply another factor of a thousand variation. But, if there is a factor of 10, is it important? Should we be doing it?

MR. HILL: This is Brit Hill from the Center for Nuclear Waste. I will be talking a bit about the probability uncertainties --

MR. POMEROY: Okay.

MR. HILL: -- and how the age is going there. But, the quick answer to your question is that, no, it doesn't result in eight orders of magnitude variation. The errors are not that big.

MR. McCONNELL: And the other answer to your question is, yes, we do try to focus our concerns or our efforts on areas that do make a significant difference. But, we would qualify that by saying that it is one thing to say that there is no effect or there is no significant difference made, and it is another thing to demonstrate that you have looked at that and you are able to -- I am going to use "demonstrate" again -- demonstrate that it isn't -- there is an effect. And I think that we would expect to see both from DOE.

MR. POMEROY: Right. But, is it NRC's job to do that?

MR. McCONNELL: No. It is DOE's.

MR. HINZE: Keith, we note that in your review of the status report prepared by Los Alamos that there was a considerable emphasis upon knowing tectonics better, getting more tectonic information and also understanding the volcanic process better. In view of what kinds of research the center should be carrying out and the extent of this research, are some of these concerns going to be alleviated as a result of this new study plan on magmatic processes? What would be the impact of that study plan on this? A related question. It is my understanding that DOE has taken to heart the criticisms of their status report and are going back and reviewing it and revising it. The -- again, if they follow through with that, what impact will this have on your research program -- your user needs, if you will, in view of them satisfying your demands, your concerns that you have expressed?

MR. McCONNELL: It could refocus both our user needs and the direction of the research at the Center. Again, there is a certain momentum that develops. But, if we are able to reach some sort of agreement with DOE about common approaches or what we think are the best approach, I would say that it could have a significant effect on the focus of our research. I think that having said that there is still, because of the nature of volcanism or igneous activity and its potential effects on the repository, a need for the staff to continue on and to maintain this level of expertise to review and also this development of an independent approach perhaps or an independent view on igneous activity. So, it could have a significant effect, but there would still be work ongoing at the center I believe. Again, it is not completely tied to what DOE is doing. We are developing our own methodology, our own approach to the review so we can make informed judgments when we get the LAN.

MR. HINZE: You are very aware of the work that DOE is doing in the volcanism issue. What work are they doing in volcanism research in contrast to the site characterization at Yucca Mountain?

MR. McCONNELL: The Center?

MR. HINZE: No, not the Center, DOE.

MR. McCONNELL: DOE?

MR. HINZE: Is DOE doing volcanism research or are they characterizing the site?

MR. McCONNELL: I think basically they are characterizing the site. I really can't speak for what beyond that that they are doing. John?

MR. TRAPP: It's really primarily characterizing the site. They are doing some "analog"-type studies, some studies supposedly down near the Grand Canyon, taking a look at some of the roots of a few of these things, that type of thing. But, I guess, my off the top of my head statement would be about 98-99 percent of the stuff would be following under the direct site characterization activities.

MR. HINZE: This is contrast to NRC's approach, which is -- which is in the volcanism issue. How much effort is put in research verses TA?

MR. McCONNELL: Research versus PA?

MR. HINZE: Percentage wise?

MR. McCONNELL: Oh, TA?

MR. HINZE: TA, not PA.

MR. McCONNELL: Okay. Technical assistance versus research. Our technical assistance varies depending on the number of reviews that are done. To give you an example, I think that the Center work on the volcanism status report required approximately half an FTE. It was quite an extensive review, quite an extensive effort, and that is one reason why we thought it was important to get the Center's comments in the public forum. I think the research effort in volcanism is in the neighborhood of seven to $800,000, if I am not mistaken. So, in relationship, it is probably maybe two to one, research versus technical assistance, but that is really off of the top of my head. It may be completely wrong.

MR. POMEROY: And that is seven or 800,000 out of a total research budget at the Center of --

MR. OTT: This year it is approximately 5.6 million.

MR. POMEROY: That is for research?

MR. OTT: For research, right.

MR. POMEROY: So, at least one-eighth of our total research budget is going to volcanology activities?

MR. OTT: Around there. The 700,000 maybe a little high. It is in that ballpark. I couldn't give you the exact figures right now.

MR. POMEROY: Sure.

MR. OTT: Bill Ott, office of Research.

MR. HINZE: Are there further questions, comments?

[No response.]

MR. McCONNELL: Thank you.

MR. HINZE: With that, I will turn it back to you, Marty, hoping that you will give us a break. I would like to thank Keith. Keith, it was very understandable. You are to be congratulated. We appreciate it.

MR. STEINDLER: Yes. Thank you very much. I gather that a break has been ordered by the elder member over to my left. So, let's take a 10-minute break.

[Brief recess.]

MR. STEINDLER: We are ready to resume. Bill?

MR. HINZE: Yes, we will turn to Bill Ott and he will explain the next several speakers as I understand.

MR. OTT: Let me say at first a welcome to Dr. Garrick. I am certain we are looking forward to many years of interaction. I do want to apologize both to Dr. Garrick and to Dr. Foland. Many of the questions that they were asking, to a certain extent, were addressed in a rather major presentation on the license application review plan by Bob Johnson that occurred when we reviewed 1406 about six months ago with the Committee. Perhaps some of that material could be forwarded to you for your review. I think it would help.

With regard to the volcanism program and the LARP process, the user needs that we are responding to were probably developed about four years ago, prior to the current LARP process. We have not seen anything yet in the LARP process that tells us we are not addressing the right things. The program was described to ACNW at that time before we actually placed any work in a rather general way in a presentation by Dr. Kovach back then. Since that time, when we began placement of the work, the first project was placed with the Center about two and a half years ago. At that time, neither Dr. Connor nor Dr. Hill were on the staff at the CNWRA, but staffing needs in that area had been identified. Since then both have come on board and we started a second volcanism project about last July. The first one was a rather general project that was aimed at trying to assess the data that is available out there and how we would move forward to assess the volcanism in a regional context.

MR. HINZE: Is that continuing then, Bill?

MR. OTT: That is the project that Dr. Hill will talk about. It has about six months to run, so that project is nearing the end of its current phase; however, it is clear from many of the evaluations that some of the work that is being done in there probably should continue. We haven't really addressed that yet, but we will as the project comes closer to its conclusion.

I think I would like to get onto the meat of the presentation then and let Dr. Hill describe what we feel the status and progress have been in that first project. Brit?

MR. HINZE: Excuse me. Is Dr. Connor going to speak?

MR. OTT: He will be the next presenter.

MR. HINZE: The next person. Okay. Fine. Thank you.

MR. HILL: I am Brittain Hill. I am one of the geologists at the Center for Nuclear Waste Regulatory Analysis, with Chuck Connor and two other members of the

Center Staff, Gerry Stirewald and Stephen Young, who are more of the tectonics people. We have been working on identifying and working with the volcanic systems of the basin and range. This is a research project that started about two and a half years ago, and will be completed by the end of this fiscal year in September. What I would just like to do is --

MR. HINZE: Which of the handouts are we supposed to be working from? We have two.

MR. HILL: It would be on this one that is volcanic systems of the basin and range.

MR. HINZE: Okay. All right.

[Slide.]

MR. HILL: I would just like to show a slide to kind of focus our attention on what the issue really is. I guess you can see some of that. The potentially adverse condition that we are worried about is evidence of igneous activity during the quaternary in the Yucca Mountain region. As you stand in Crater Flat, looking up towards Yucca Mountain proper, you can see that there are about six volcanos that occur within 20 kilometers of the Yucca Mountain candidate site. There are actually two of them that are around 1.2 million years old that occur within 10 kilometers of the proposed repository site. So, it seems very intuitive that the potentially adverse condition --

evidence of that igneous activity during the quaternary is present in the Yucca Mountain region. Since we have this activity, we have to be concerned then with determining both the probability and consequence of igneous activity and its potential threat to the repository.

In order to meet these research needs, in conjunction with NRC Research and NMSS, we have developed two basic research projects at the Center. The one that I will be talking about today, the volcanic systems of the basin and range, has been designed primarily to put the Yucca Mountain area into some sort of a regional volcanic and tectonic context, to sort of develop and test probability models for igneous activities within the Yucca Mountain region and also to construct models for regional and local tectonic control on igneous activity. Some of this might be familiar. It really goes back to some of the user needs -- 601 and 602, where we were examining probability -- or excuse me -- when we were examining the past patterns of basaltic activity both within the Yucca Mountain region and the surrounding basin and range, and also trying to get a better handle on what sort of geologic processes control the location and distribution of volcanoes within the basin and range in general and Yucca Mountain in specific.

The second research project that started last --

MR. POMEROY: Before you go there, it doesn't fall under the quaternary igneous activity portion that Keith was discussing under the LARP review, because it deals with probabilities clearly.

MR. HILL: Right. It's -- the probabilities section has been put in here more by immediate need.

MR. POMEROY: That's right. I understand.

MR. HILL: There is a necessity to conduct some research in probability rather than the specifics of user need 601 or 602. I think you could broadly look at that as developing probability models as being a legitimate function of characterizing spatial and temporal patterns in volcanic fields.

The other research project which started last July is the field volcanism project. That quite simply is just looking at direct and in effect potential direct and indirect potential consequences of igneous activity on repository performance. There is some overlap conceptually and in principal between these two research projects. Some of what I will be saying could be construed as being field volcanism. Some of what Chuck is saying in field volcanism could be more for characterization. So, it is really important to remember these aren't two very distinct and separate research projects. There is some overlap and an awful lot of coordination between them.

MR. POMEROY: Help me out there a little bit. When you said it started last July, as I remember it, that was about the time frame of the NRC/DOE technical exchange on the LANL --

MR. HILL: Right.

MR. POMEROY: -- report. Was thi activity undertaken as a result of that report --

MR. HILL: No, it was not.

MR. POMEROY: -- or was this activity planned for years before that time?

MR. HILL: This had been planned before we had received the preliminary draft Los Alamos report where we had identified that the volcanic systems of the Basin and Range Research Project would not address certain very specific issues in volcanic consequence. We received a -- excuse me?

MS. KOVACH: Yes. I think the -- Linda Kovach, Research -- the easy answer to this is that this project was designed a good four years ago, and is now being implemented. And I think that -- well, that is the answer.

MR. POMEROY: That is the answer.

MR. FOLAND: Could I ask -- if you want to add a comment or two -- how this project interfaces with let's say parallel projects that are going on in terms of tectonics? There are other projects in tectonics which presumably have subset of volcanism related to them.

MR. HILL: Right. They do where we are examining structural controls on dike propagation, whether or not pre-existing structures, such as faults, can channel magma up into the surface. For example, would the faults around the Yucca Mountain area serve as a focus of magmatism or would there be no effect?

There is also a real regional linkage between the tectonics of an area and the volcanic characteristics of an area. I will be touching briefly on some of that later in this talk. We are also interfacing quite a bit with performance assessment, trying to determine what sort of uncertainties exist both within the geologic literature and within the specifics of the site and whether or not our research program can address these uncertainties.

MR. HINZE: What is the origin of that term field and field volcanism?

MR. HILL: That is the title.

MR. HINZE: I don't understand that.

MR. HILL: It was -- the focus of the field volcanism project is directed studies at specific analogous volcanic centers. There is some numerical modeling and some conceptual modeling as well. But, the gist of the research is directed toward going out at appropriate historically active volcanos and basin and range analogs to conduct field work. There is not too much significance to the name. It is a place keeper.

MR. HINZE: So, really it would be more appropriate to say analog volcanism; is that correct?

MR. HILL: Correct. That would work just as well.

What I would like to do this morning is talk about three of the major findings to date within the Volcanic Systems Research Project, first taking a look at a review of dating techniques for quaternary volcanic rocks. This was conducted as task 3 of the volcanic systems project and directly relates to user need 605. One of the sources of uncertainty in the volcanism project in general is that every date for a volcano out in the Yucca mountain region has an associated uncertainty with it that represents not only the precision of the analysis, but the accuracy of that analysis in actually determining the age of a volcanic process. We have undertaken a very detailed review of the methods that are used to commonly date quaternary rocks and also the status of the available data for the Yucca Mountain region dates.

MR. POMEROY: I think when you mentioned the volcanos closest to Yucca Mountain, 10 kilometers from Yucca Mountain --

MR. HILL:

MR. POMEROY: -- that you indicated the data 1.2 -

-

MR. HILL: Plus or minus 0.4.

MR. POMEROY: 0.4?

MR. HILL: Yes.

MR. POMEROY: Thank you.

MR. HILL: That would be Northern Cone and Black Cone of the Crater Flat alignment.

The second topic I would like to discuss is putting the Yucca Mountain basaltic system into some sort of a regional volcanic context. As we will be seeing a little bit later on, not all areas of the basin and range are appropriately analogous to what is going on within the Yucca Mountain region. There are some very important distinctions that must be kept in mind when we are discussing volcanism in general and volcanism in specific within the Yucca Mountain system.

Finally, I would like to give you a brief overview of a geographic information that we have been developing that has been geared towards handling this plethora of scattered data throughout the geologic literature relating to basin range volcanic systems. I will give you an idea of what we are going to be doing with this sort of a GIS.

I will start off by taking a look at the geochronology issue. We have completed a fairly substantial report that reviewed and analyzed the dating techniques that are commonly used in the Yucca Mountain region on young volcanic rocks. There are four major conclusions that can be derived from that report. The first of them is that the age uncertainty for volcanos that are less than about two million years old are relatively large. These uncertainties can impact probability calculations. A lot of this centers around the uncertainty of the crater flat volcanos. When you take a look at the range of data that are available for some of these volcanos in Crater Flat, the age range is between 1.9 million years and .95 million years for the same vent and the same flow. So, there is quite a bit of uncertainty into what the actual age of eruption is within these volcanos. When you factor that uncertainty into an average age calculation, you come up with an age of 1.2 plus or minus 0.4 million. In a very simple sense, if we are to look at the old range of uncertainty, let's just assume then for the probability calculations that the age is 1.6 million years old. Using the nonhomogenous poisson model that Chuck will be talking about a little bit later, we are ending up with a probability of direct volcanic disruption of the repository within the next 10,000 years of about one times 10 to the minus fourth. There is also some uncertainty associated with that age. If we are to assume though that the quaternary volcanos are all about 800,000 years old, that increases the probability from one times 10 to the minus fourth, up to three times 10 to the minus fourth. This is only for direct disruption. Now, I know that number --

MR. POMEROY: This is for 10,000?

MR. HILL: For 10,000 years.

MR. POMEROY: This is not an annual capability?

MR. HILL: No, this is not an annualized, this is for 10,000 years.

Now, this is only for direct disruption and only within a very specific area of the repository. The significance of this difference is not in the absolute value of one times 10 to the minus fourth and three times 10 to the minus fourth, but how these are going to be combined into iterative performance assessment models, where the cumulative effect of disruptive processes may be critical. Because, if we are getting a number of three times 10 to the minus fourth, four times 10 to the minus fourth processes, the cumulative effect of that is a normalized probability into that 10 to the minus three region, which could then very directly affect repository performance in the sense of the EPA standard.

I would also like to add that that uncertainty of 1.2 plus or minus 0.4 million years can be reduced significantly by using more appropriate dating techniques that are more precise and accurate than were available literally a decade ago.

MR. POMEROY: Would DOE be in agreement with these numbers, in essence?

MR. HILL: I believe they would have to be. The one caveat I would put on there --

MR. POMEROY: That is not what I asked. I asked -- I agree, you know, that you certainly have confidence in your own work. But, the question is one of trying to resolve some of these differences. Are these the same kind of numbers that are incorporated into the INEL report?

MR. HILL: There are two points I would like to make. First, there are a number of unreported dates that have been used in some of the geologic presentations by DOE staff. We have never seen these data, nor have they been published. But, the second determination is that somehow these unpublished dates represent the most likely age of certain volcanos. All we have available to us is what has been published in the literature, not some unpublished personal communications. So, that is where we are looking at. We cannot tell the difference between a 1.9 million year age for a volcano and a 1.8 million year age for that volcano. They do not overlap. One of those dates is inaccurate, but we cannot make that determination right now.

MR. POMEROY: But, the answer to my question is no apparently?

MR. HILL: Apparently, no.

MR. FOLAND: Let me ask the same question my way. That is would DOE agree with your analysis here, that is taking the 1.2 plus or minus 0.4 event with that uncertainty? Would they get the same change in the probability that you get -- that is the factor of three? Would that subscribe to that analysis being correct?

MR. HILL: I think they would. This is a very straight-forward uncertainty -- how you would -- again, the proper way of doing this is propagating that uncertainty directly through the probability calculations rather than in the simple sense that I have just outlined of 1.6 versus 0.8. We have yet to incorporate any uncertainty into any probability model or even discuss the limitations of the data used to present the model. I know that sounds harsh, but it is the way that it has been presented.

MR. FOLAND: So, the answer is whether or not they would agree is totally unknown because they have, to your knowledge, in terms of what is written not done the analysis?

MR. HILL: From what they have presented, they have not incorporated uncertainty into their probability models in the sense of there is an age uncertainty in the data. That is exactly what they have done.

MR. STEINDLER: I have two questions. One, are you addressing an age uncertainty of a single event, and two, can you give some clue as to why you think there is such an apparently unusually large error in this particular case?

MR. HILL: Okay. First, the uncertainty in a single event has not been determined. There is currently a working hypothesis that some basaltic volcanos may have multiple eruptions separated by tens of thousands of years where there is no volcanic activity. Gene Smith and some of his coworkers at UN-Las Vegas have had a preliminary -- at least some discussion that there could have been multiple eruptions at the Red Cone Volcano which is within this 1.2 plus minus .4 range -- that the adjacent Black Cone Volcano represents a single event. It would be very premature of me to say that we understand how many events are represented by all of the quaternary volcanos out there. I think, in all likelihood, a conventional model would be that these dates represent a single process and that the inaccuracy of the data reflects the inaccuracy of the technique, not a volcano that has been active from 1.6 to 0.8 million years.

The second part of the question I forget.

MR. STEINDLER: It is why is there such a -- to what do you attribute this relatively large -- apparently large error?

MR. HILL: Most of these dates were produced in the early 1980s by conventional potassium argon dating techniques. They have very low radiogenic argon yields to them. A good empirical relationship is, if you have under about 2 percent radiogenic argon, there are usually extreme problems in precision and accuracy of a date. These are difficult rocks to date by conventional methods. They are very low in potassium, the radiogenic parent for argon, and they are also -- they don't have any phases that are extremely stable that trap the daughter, argon, to them. There has been, however, within the past five years, a more routine development of very clean potassium argon systems that are geared towards dating basalts, low-potassium basalts of about one million years to younger. There are also incremental argon techniques that can be used to refine some of these dates.

Unfortunately, most of the dating effort within the Yucca Mountain region has focused on Lathrop Wells, which is the youngest volcano in the system. And there really has been no work done on characterizing the age of the other quaternary volcanos since about 1983.

To look at some of the older volcanos, conventional dating techniques are certainly appropriate. Some of the older dates can be both reasonably precise and accurate for many of the older volcanos -- the things that are oh about two million years to even eight to 10 million years. The uncertainties lie not in the analytical technique itself, but just in the number of samples that have been done on certain volcanos. A number of these volcanos are very incompletely characterized. It is difficult to tell form DOE study plans what geochronology studies have been completed and what will be effected later on in the program. So, it is uncertain from our perspective whether or not some of the older volcanoes -- we will really understand what the age of them are.

It is important though to mention using the nonhomogenous model the significance of that uncertainty is very small, because one of the values of the nonhomogenous model is we are looking at the influence of young volcanic centers that occur spatially close to a target area. Older volcanos that are kind of far away really don't affect the probability that much. So, this is more of a characterization issue than a really key problem in resolving probability studies with the age available.

MR. GARRICK: Let me ask one other thing as a point of clarification. Do you consider this range that you have presented up here in red pencil, the one to three, do you consider that a wide range of uncertainty?

MR. HILL: I think it is a range of uncertainty that is addressing one parameter, the uncertainty and the age. It does not address the uncertainty and assumptions within the model itself.

MR. GARRICK: Yes. But, even that, from the world I come from, I wouldn't get too concerned about that. That, to me, in the 10 to the minus four space, for example, I don't view that as a very significant --

MR. HILL: Well, one of the real primary significances to that number is classifying an event as significant --

MR. GARRICK: Yes.

MR. HILL: -- whether it has the 10 to the -- 10,000-year probability of greater than one in 10,000 in 10,000 years or less than one in 10,000 in 10,000 years. One of the most significant findings in the preliminary draft of the Los Alamos Volcanism Status Report was the conclusion of the authors that the most likely probability for repository disruption was 6.5 times 10 to the minus 5th in 10,000 years. The inherent conclusion from that is that volcanism is not a problem from a regulatory aspect. So, I see, first of all, that range of numbers as validating that volcanism is, from the guidance we have received from the Code of Federal Regulations a potential adverse condition. And second, by itself, it is not a large range in values; but, in a cumulative performance assessment sense, this may be very critical in determining overall system performance.

MR. CONNOR: May I just add one thing? My name is

Chuck Connor. I just wanted to point out that this range in values -- Brit essentially said this, but I just wanted to reemphasize it -- is a result from one model with its own starting assumptions. What we are looking at is the variation produced by simply uncertainty in geochronological information. What we will eventually wind up with is a great range of numbers. And, I think it is important to keep in mind that here we have got one probability model which produces this range and represents an attempt to look at the sensitivity of probability of disruption to a parameter -- the geochronological information. Whether that eventually is deemed to be an important variation or not, you know, that is a good topic for debate. But, here is the range, and this is the first model ever to calculate that for the Yucca Mountain region.

MR. STEINDLER: Thank you.

MR. HILL: Another conclusion of our dating techniques review was that conventional dating techniques are very unsuitable for the Lathrop Wells Volcano. Our best estimate from some non-conventional techniques that are primarily around exposure dating would indicate that Lathrop Wells is probably round 100,000 years old. The conventional dating techniques, by that I mean potassium argon and argon argon give a wide range in ages with very large uncertainties attached to them. That does not indicate that the labs are inaccurate, but rather that very young low-potassium basalt -- you just can't date it by conventional techniques.

And, again, by looking at exposure age dates, mainly 3 helium and 36 chlorine, as well as a couple of internal isochron uranium/thorium dates, the age of Lathrop Wells is around 100,000, plus or minus 50,000 years. Two points to that are, first, that that uncertainty really doesn't affect the nonhomogenous probability model very much. Chuck will get into some of the details of that.

Second, there is a lot of controversy surrounding whether or not Lathrop Wells and other Yucca Mountain volcanos have had a number of eruptions through time. This uncertainty really makes it difficult to attach a numeric age to potential gaps in the volcanic history of Lathrop Wells. I think that is still a real ongoing topic of discussion and one that we are not going to be able to resolve solely by geochronologic argument. At 100,000 years, we probably can't see age differences of several thousand years between similar composition of flows. It is going to be a subjective judgment.

MS. DEERING: I had a question. I recently heard that it was 4,000 years for Lathrop Wells in several different meetings, and I wondered have you heard that.

MR. HILL: Those dates, first of all, have only been presented at a high-level waste paper where they're reported with, essentially, no discussion of analytical technique. That's one out of three dates that have been determined on some ash beds that occurred on one of the, I think, western quarry walls in the Lathrop Wells cone. That quarry wall has since been removed.

They are compositionally distinct, the ash beds, and that's part of the problem is they cannot be correlated to any known Lathrop Wells unit. They're compositionally distinct, but you go up to the summit of Lathrop Wells and sample the composition of bombs up there, they don't resemble the ash bed. They look similar, but not in the sense of breaking out distinct chemical units at Lathrop Wells that Crowe and Perry have done. You just have a problem with that.

MR. NELSON: Can I clarify that?

Steve Nelson, Woodward Clyde.

MR. HILL: Yes.

MR. NELSON: Those are TL dates, thermal luminescence dates on soils above and below that ash that you're referring to.

MR. HILL: Right, and that's the second point I was getting to, that it's unclear what those thermal luminescence dates truly represent.

MS. DEERING: Thank you.

MR. HILL: So I think in the absence of being able to c relate it to Lathrop Wells, there is a big problem on what those data truly represent.

What I'd like to do is put the Yucca Mountain system into some sort of a regional context and give you an idea of why we're worrying about other analog systems within the basin and range.

With just the very general tectonic map of western North America, you can see a large area that extends from Mexico up into Oregon, out towards the Colorado Plateau that's been highly extended with generally north trending normal faults and associates basins. The Yucca Mountain Region is located within this basin range-type providence, but over towards the western margin where the influence of the San Andreas fault and the northwestern motion of the Pacific Plate is giving us a little additional sense of sheer into the Yucca Mountain Region over the normal east-west sort of general extension within the basin range.

Since about five million years, volcanism has migrated to the margins of the basin and range province, and over where within the Rio Grande riff and around the Colorado Plateau. There really hasn't been too much large activity within the central part of the basin and range, with one or two sort of localized exceptions.

One of the favorable conditions about the Yucca

Mountain site is that there really aren't too many volcanoes there compared to some other fields, like the Luder crater or Pancake Revelry Range where there are tens of volcanoes, with only a few within the Yucca Mountain Region.

I think from a hazard sense, that's a pretty good idea. You certainly don't want to put a repository where there's a hell of a lot of volcanoes coming up, but as far as characterization and modeling, you have a very difficult time in dealing with those few data points. So we need to go to appropriate analogous systems to examine some of the things that may not be present within the Yucca Mountain Region.

First of all, the basaltic volcanoes within the Yucca Mountain Region have many features that are no longer accessible. The temperatures and degassing and mass flow rates within these volcanoes has ceased right after the eruption. We can't go there and quantify what sort of temperatures these volcanoes produce in the surrounding wall rock.

A lot of the distil, unconsolidated ash has been stripped off by erosion, and that makes calculating the volume of the basalts very difficult when you don't have a potentially significant part of the eruption preserved. So, again, we have to get a much better understanding of what kind of volcanoes can erupt as an ash component before we have any confidence that the volume of the eruption is represented solely by what's remaining at the volcano itself.

Also, we can't really go underneath the quaternary volcanoes in Yucca Mountain and understand much about their plumbing system. So we've got to go into older fields where the subsurface intrusions that feed these volcanoes are exposed to examine potential interactions between intrusions and dikes and the surrounding repository and wall rock.

The other concern is that because we only have a few volcanoes in the Yuc Mountain Region, these volcanoes may not be representative of the full spectrum of volcanic activity that can occur within this kind of a volcanic system.

One of the things that we've seen in analogous modern volcanoes is that there's a wide range in the explosivity of these events. This is a picture from the 1975 eruption of Tolbachik where we're looking at the early stages of Cone IV, and this would be a good characteristic of a sort of strombolian eruption in the classical sense where we have a glowing cloud, a lot of incandescent rock, molten rock being shot out over a fairly short region. There's no large plume of ash that gets transported up into the atmosphere and carried down range very far.

This is very representative of a low-energy basaltic eruption. There are examples of these throughout the basin and range and within the Yucca Mountain Region.

This is also a basaltic volcano during the Tolbachik eruption during the early stages of Cone I. We have a very energetic eruption here where there's very little incandescent scoria being shot out ballistically. There's enough energy in this system to rip that scoria apart, keep it hot, shoot it up -- in this case, 12 to 15 kilometers is a sustained eruption column for about 2 days -- and transport that ash anywhere between 500 and 1,000 kilometers down range, depending on which way you went.

There's also some evidence within the basin and range and within the Yucca Mountain Region that this kind of explosive activity can occur in this volcanic system. So [illegible] can see if we're trying to develop consequence models, [illegible] really have to get a handle on whether or not we want this kind of a model or the classic sort of low-energy strombolian model that permeates the DOE study plans and document.

Chuck will talk a little bit about some of the work that we've been doing at historically active volcanoes. What I'd like to do is focus a little bit more on what we consider to be appropriate basin and range systems and how we're making that sort of determination.

One of the things that's pretty apparent from the literature -- first, let's focus in on the western basin and range that encompasses the Yucca Mountain Region -- there's been an awful lot written in the past decade about what sort of composition and time controls occur in some of these basaltic systems throughout the basin and range.

One of the very firm conclusions is that a basaltic volcano is younger than about five million years, originate in very distinct kinds of mantle beneath the crust of western North America. The reason these mantle compositions are important is that the source composition can dramatically affect the volatile content of the magma system and also the amount of material that flows through the system.

By volatile content, we're looking at dissolved species such as CO_2 and H_2O that when we get to the surface are going to come out of the magma, form a gas phase, tear the magma apart, and erupt it up to the surface. It's the volatile content that is the primary control on the explosivity of eruption.

Now, the Yucca Mountain Region lies in what's generally referred to as the western Great Basin mantle province. The salts within that province originate in mantle material that has been enriched in a lot of incompatible elements, including water, and just as a very general oversimplification, we're looking at a system that starts out with a lot more volatile contents in it than something that would occur up to the north in the Pancake Range, for example.

The Pancake Range originates in mantle material that has not been enriched. It's a much lower water content, perhaps a much different sort of volcanic evolution through time than we're seeing in the Yucca Mountain Region. So, if we're going to go out and look at eruption explosivity, it's probably a good idea to start looking at these sort of fields before going up here as a characteristic of what could occur within the Yucca Mountain Region.

In addition, if we're trying to construct long-term petrologic models about whether the Yucca Mountain system is waxing or waning or has remained a steady state for the last 10 million years, we have to look at volcanic fields that have a very similar evolutionary trend.

A characteristic of these central basin and range systems that are represented by the Pancake Range is that there has been very dramatic changes in the processes that control basaltic volcanism within the past five million years or so. There are very dramatic shifts from a vigorous system down to a system that's compositionally distinct and classically waning in activity.

It is, however, incorrect to assume that the trend of waning magnetism that you can see here can be applied to the Yucca Mountain system because you're starting off with a fundamentally different mantle source and a fundamentally different system.

MR. POMEROY: Brit, just help me out a minute as far as this is concerned. I just want to get a feeling for it.

I doubt if anybody, including the DOE, would probably disagree violently with the first three bullets that you have there.

MR. HILL: Yes.

MR. POMEROY: Talk to me about the last three bullets. Would the DOE disagree with those three statements?

MR. HILL: The DOE has failed to address how water content can affect nearly every volcanic process. In fact, they've ignored it in many of their petrologic arguments in the status report.

I don't think that Frank Perry, in particular, would disagree with these last three statements because he's written and co-authored at least two papers that have said the last three bullet conclusions that these are very distinctive systems, and that's why we're kind of at a real loss to explain why the volcanism status report used this figure from Fitton et al., 1991, and erased this line, kind of blurring all of these distinctions between central basin and range and western Great Basin volcanic systems because Frank Perry and Bruce Crowe are well aware that these sort of compositional distinctions can be very important.

MR. POMEROY: So they would agree.

MR. HILL: Yes, based on -- I'm always reluctant to say they would agree --

MR. POMEROY: Why, of course.

MR. HILL: -- but based on what they have written --

MR. POMEROY: Yes. I understand.

MR. HILL: -- that's completely in line with these last three conclusions.

Our research efforts in volcanism have focussed on western Great Basin systems. We're not going to ignore central and peripheral basin range systems, but if we're trying to get some quick answers as to what's going on in Yucca Mountain, we're much better off looking at something like the Big Pine, Death Valley, or even the Coso system than we are going over into the Grand Canyon area and trying to look at long-term evolutionary processes.

MR. POMEROY: I guess that's what they wouldn't agree with. Is that your assumption?

MR. HILL: We have several comments on study plans about demonstrating how proposed studies at, essentially, Colorado Plateau and margin fields will yield the exact information they need to address Yucca Mountain problems in volcanism. So that would be a formal comment that has yet to be resolved with the DOE researchers.

MR. POMEROY: I'd like to have your opinion at some point before you finish in terms of how many of these specific problematic areas that you've identified are going to be resolved -- and I'll use that term deliberately -- in the next year, in the next 10 years, and in the next 100 years.

MR. HILL: In all fairness, we've only begun to address many of these issues, and in fact, the DOE has not had an adequate time to respond to our comments in many of these instances, especially for study plans.

I think it's very premature to say that we'll be able to resolve these until we have seen responses to study plan comments and also to how we've seen the revised volcanism status report.

We get an indication from the letters that they're incorporating many of these suggestions and addressing many of these concerns. So I'm optimistic that we're going to be able to settle a lot of this.

MR. POMEROY: I guess I'm wondering about your research specifically, this particular set of studies. Is this going to be something that you feel will terminate in

10 years with some sort of resolution of the objectives that you have for this research not related to DOE then?

MR. HILL: We have already reached resolution of a number of items about whether probability is an important issue, whether volcanism is a disruptive scenario in the EPA sense of the word. Also, the analysis of geochronologic uncertainty and propagation of geochronologic uncertainty, we're moving towards that.

I see our research project as addressing and resolving to the best extent possible, given the time and money constraints that we have on this, to addressing whether or not the consequences of activity are going to be definable, defendable, and bounded correctly.

I don't know if we're ever going to resolve the issue in that classic sense, but our research plan will put some very defendable constraints upon it.

MR. POMEROY: Well, for instance, do you feel at all with the age determination arguments that are currently going on will be resolved in the next 10 years?

MR. HILL: Again, I can't say because I don't know what additional geochronological work the Department of Energy plans to do as part of site characterization.

When you look at the study plan, it says we will date all the major volcanic systems out there. Well, the study plan was written anywhere from 1988 for the site characterization. Up until very recently, most of the data that they cite, though, has been produced five to seven years before the study plans were written. Does that mean that the dates that are currently available are all that's going to be done or that additional work to constrain uncertainty will be done?

I think that's an open item right now, but that is this sort of analysis, this important document, why we think there is additional work and, realistically, a very small amount of work that would need to be re-done to resolve some of these large uncertainties in the probability models.

Keith McConnell.

MR. McCONNELL: Keith McConnell.

I think I'd just like to expand on that a little bit. I think what we're attempting to do is raise the issues and then let DOE develop an approach to addressing them, and that could include a variety of mechanisms, a bounding analysis or other mechanism to address the uncertainty.

So I don't think it's as dismal or pessimistic as it sounds. I think there are ways to approach the issues that the center has raised and the staff has raised in its letters, and so I think there is a path to resolution, and perhaps one of those paths is a revised volcanism status report.

If they are at least addressing the issue and we can clearly identify that they are addressing it, then maybe they've bounded the problem. Maybe we can move on.

MR. POMEROY: Thank you.

MR. HILL: One of the things about the basin and range is that there's been an awful lot of work there, literally, in the past century.

This wide amount of varied data types has never really been compiled together to try to link a lot of the volcanic and tectonic information into one sort of a unified database.

One of the problems with this is that there's just an incredible variety of data available for the basin and range volcanic systems, and it ranges from publications in the peer review literature down to master student theses that are done in really well-qualified universities with talented people, State reports, contractors reports, open file maps from the Geologic Survey. All of this data needs to be brought together and examined in a consistent sort of format.

A lot of the quadrangle maps, for example, have never really been pieced together to give a complete map of a volcanic field for many of these areas in the basin and range.

The other point that we're going to need to address in understanding basin and range-type volcanic systems is that we have to look at both tabular and spatial data to develop any sort of defendable probability and consequence model. By tabular, I mean straight, old numerical data, things like the age of a volcano or its geochemical composition. We need to combine that and intimately link that data to spatial data such as vent locations or the bedrock geology or proximity to certain fault zones.

This is the basis for our research task in constructing a geographic information system in order to link up the spatial and tabular data. Once we have constructed the system, we're going to be able to evaluate the completeness and accuracy of the DOE license application and also examine a lot of the models proposed in their research. It's also going to allow us to quickly access, since we're only going to have three years to review the license application, allow us to quickly access this data and present it in a very coherent format, and also, it's going to serve us in developing and testing conceptual, empirical, and numerical models for volcanism both within the Yucca Mountain and the basin range as a whole.

MR. HINZE: How much overlap is there with what DOE's doing? They are establishing extensive GIS systems. Collecting this data, that's part of the whole site characterization program.

MR. HILL: In part. A lot of that effort to date has focused exclusively on Yucca Mountain and the Yucca Mountain Region. It's unclear how many additional volcanic fields will be included in their database. I think it's very important to remember that we're going to need to review completeness and whether or not the available data has `een brought to bear on these questions.

MR. HINZE: You must know how far they're going out. That would give you access to the data that they have out to whatever distance they're going, right? Are you using their databases or are you starting over?

MR. HILL: We plan to use their database for the Yucca Mountain Region.

MR. HINZE: What do you call region, if I may ask? Is this the 100-kilometer radius?

MR. HILL: I think that's the extent of it, but I am not sure. I am also not at all sure about how much additional information outside of that Yucca Mountain Region will be incorporated into the DOE database.

MR. HINZE: Your position then is to understand the volcanic system at Yucca Mountain; that one needs this database and needs to extend it out over the entire western Great Basin volcanic region. Is that right?

MR. HILL: I don't know if it has to be the entire western Great Basin volcanic system, but, certainly, I believe very strongly that we need to examine some appropriate analogous systems in addition to Yucca Mountain at the same sort of detail that we're scrutinizing the Yucca Mountain volcanic system.

MR. HINZE: But in the western U.S.?

MR. HILL: In the western U.S. and also for historically active volcanoes. That research is directed towards different goals, but it's still that we need to look at analogs. I think that is an underlying theme in this whole presentation because there are few volcanoes in the Yucca Mountain Region, and we just don't have any confidence that that's the limit of potential activity.

MR. HINZE: Tell us ignorant ones where Tolbachik is.

MR. HILL: It's in Kamchatka Peninsula of Russia on the far eastern side, northeast of Korea.

MR. HINZE: Is that an analogous basaltic system?

MR. HILL: It's an extremely analogous basaltic system in that it is originating --

MR. HINZE: In a back arc system?

MR. HILL: Pardon?

MR. HINZE: What is it in? A back arc system?

MR. HILL: No. It is right within the arc. It is originating from enriched mantle material that has the same enrichment process that occurred within the western Great Basin. It just is happening now rather than millions of years ago. It's originating through a crust that's 40 kilometers thick as opposed to around 30 to 35 kilometers thick, in a very extensional tectonic regime, in a composition that is very similar to many of the volcanic systems in the western Great Basin.

It has similar volatile contents, the best that we can determine, and similar eruption styles and volcanoes to what we see in the western Great Basin.

MR. HINZE: So it's in the Russian literature then?

MR. HILL: This is in the Russian and American literature and the international literature.

I thoroughly understand it doesn't seem -- like, why would you go to Russia to look at western Great Basin volcanic activity? The problem is that there are no historically active volcanoes in the western Great Basin. We can't go to them to look at a lot of these eruption processes. We're having to infer what happened based on the deposits, and the level of inference is very high, and there's a large uncertainty to that because there just hasn't been this direct observation to tie the eruption dynamics back to the resulting deposits.

MR. POMEROY: I think I understood you to say that we should look at some of these analogous systems at the same level of detail that the Yucca Mountain has been looked at.

MR. HILL: Yes.

MR. POMEROY: Given the fact that Yucca Mountain has been looked at for a period of time now, given the fact that probably the investment is extremely significant, and I suppose you have some idea about that.

What do you think it would take in terms of time and effort and money to look at all of these volcanic systems in the same level of detail?

MR. HILL: Okay. By level of detail, I do not mean to the depth and time or expense that has undergone at Yucca Mountain, and perhaps I have misspoken about that.

First, I am not proposing that we examine all volcanic fields in the western Great Basin that we have to select appropriate analogous ones and gather as much information as possible, and that is the point we're at right now of trying to determine what is available and is that level of detail sufficient to test conceptual probability and consequence models.

There has been a huge effort at Yucca Mountain to characterize the volcanic activity, and I would not want to say that we have to go to Big Pine and have that same decade-long process, but there is a lot of good, high-quality data available. It just has to be pulled together and worked with a bit to see whether or not we can move forward with what is available at a high level of detail or whether or not we need to have some additional information to test consequence models or to test probability models.

It's a large task, but a lot of it is being done very efficiently by using this geographic information system.

MR. STEINDLER: I got hung up on the slide before this one. You don't need to put it on, but you had six statements which may well be characterized as declaratory truth.

If I were to be able to find three dozen volcanologists, or whatever you folks call yourselves, and put them in a room together and ask them to identify the acceptance or rejection of those six statements, would I get a normal distribution?

MR. HILL: Well, a normal distribution for a volcanologist is kind of like hurting cats. I guess it's possibly normal, but highly skewed and crotonic as well.

I think, again, I take it that we can support the details of those statements and the general comments and specific comments, I think, that they are reasonable and representative of the state of understanding that not just myself, but other people that work within these systems would agree to.

We are going to be having a peer review of our volcanism research sometimes within this fiscal year where we're going to be asking just those sort of questions in addition to the peer review that we've solicited in our study plan -- or excuse me -- our project plan development and also in a number of our reviews.

MR. POMEROY: Those peer reviews are going to be by independent folks from the university academic community, primarily?

MR. HILL: Almost exclusively from university people, just to try to maintain a complete independence and a very objective peer evaluation of what we're doing.

MR. FOLAND: Could I address Dr. Steindler's comment because I have an opinion upon what the distribution would look like with these half-dozen bullets.

I think if you were to ask a given scientist whether or not they would subscribe to it, then I think you have to put the qualifier as are you willing to bet your month's salary on whether or not this statement is right, and I think the distribution changes.

MR. STEINDLER: Changing quite a bit.

MR. FOLAND: Right. I think the distribution changes when one asks that sort of question. For example, it's not clear to me that the Yucca Mountain lavas have higher water contents than things from Cima or Pancake. Frankly, I'm not sure whether that's been looked at very carefully in terms of the lavas at Yucca Mountain, what the intensive parameters were, what the water contents are.

MR. HILL: I agree, but as a general statement, wouldn't you agree that continental volcanoes, such as evidenced by arcs or basin and range, would start to have higher volatile contents than something like Hawaii that originated within a primitive spheric source?

MR. FOLAND: I understand that, but your bullet doesn't say that. It says Yucca Mountain Region basalt originated in enriched mantle, higher water contents, and that's not clear that the water contents of Yucca Mountain are necessarily high, even though your general point of the water content being related to the mantle source, of course, most people would subscribe to that point, I think, without much question.

MR. HILL: I am only able to highlight some very general arguments here.

MR. FOLAND: I know, but Dr. Steindler is after the issue of whether or not one can resolve some of these points, and I think we all recognize it's difficult to reach resolution on some of these.

MR. HILL: I think directed research towards understanding initial volatile contents of magmas would resolve that issue. Unfortunately, those studies have not been done for basaltic systems. We are attempting to originate some of that work in examining melt inclusion contents using secondary ion mass spec over at Arizona State.

MR. HINZE: Are they in any of the study plans?

MR. HILL: That's one of our open comments of how volatile contents will be characterized using the available studies in the study plans because we cannot see how in the absence of direct study by trying to determine primary volatile contents that this is going to be anything more than a very subjective and interpretive argument.

MR. POMEROY: So the center is going to carry on this research because DOE is not doing it. Is that my derivative?

MR. HILL: I wouldn't put it that way. What I would say is that nobody is doing this sort of activity. It is our position that analogous systems are necessary, not just in Yucca Mountain, but in volcanology in general. You can't look at an isolated segment of a process.

In order to have a solid basis for constructing consequence models, it is critical to determine volatile content, and we have identified a procedure that is almost routine now what has been recently developed for examining inclusions in minerals that have trapped some of that early-formed magma and also to look at mineralogical relationships to try to constrain the volatile content and degassing history, perhaps, of a magma.

MR. POMEROY: Do you see any problem with that? I do. You've identified a problem, and then the center undertakes the research to resolve that problem. Why not simply say to DOE that problem must be resolved? Why should the center do this research?

MR. HINZE: Well, it's not research; it's characterization.

MR. POMEROY: But it's not characterization if you're doing analogous --

MR. HILL: We're examining a wide range of volcanic systems to try to independently construct consequence models in order to evaluate the completeness and the range of models that will be and may be proposed by the Department of Energy, but I think it's very important for us to have an independent technical basis to assess many of these DOE site characterization activities.

MR. POMEROY: We are agreeing with that.

MR. CONNOR: Could I interject something here? I'm Chuck Connor.

I'd just like to point out that it has been stated in the literature by the DOE. Particularly, Greg Valentine has done quite a bit of work on eruption dynamics models; that they are going to use numerical models to estimate the consequences of small-volume basaltic activity at Yucca Mountain.

Inherent in every one of those models is water content, and so far in the models they've presented, they use water contents up to half-a-weight percent, okay?

Now, it's our job, the NRC's job -- and we're trying to help them -- to be able to test those models and decide whether we believe these models encompass the range of activity that can be for Yucca Mountain. So, if we're going to do that, we're going to need to know something about the volatile contents in those magmas.

The DOE is not doing that work now, and it's not really that big a deal. I mean, as Brit said, it's a pretty standard method. We'll put a few thousands of dollars into it and start coming up with some water contents. Now, perhaps if we decide in a systematic way that all the water contents we get are higher than have been encompassed by DOE models, maybe we'll wind up recommending to them that in a very systematic way, they go through the volcanic succession at Yucca Mountain and determine all the water contents.

What we're going to do is constrain one parameter that we know is going to be really important in testing numeric models for eruption dynamics, and in order to do that, we've just got to get some data. We have to be able to point to something real and say your model encompasses this parameter in this range. We have some evidence that another range, maybe, ought to be considered as well or perhaps a broader range should be considered, but before we say that to them, we want to have some data, too. We need to get a few of these analyses in.

As I said, we're not talking millions of dollars to do this. This is a pretty straightforward way to bring an issue to their attention and have them respond to it if we have data. I mean, they're scientists. They're not going to respond if we're just waving our arms around. We need some data to give it to them and say, look, this is important, check it out.

MR. HINZE: Keith, did you want to add something?

MR. McCONNELL: Basically, just to say the same thing. We've identified the problem to DOE, but our basis is fairly weak. We have this concept that this may be important and it may be a factor. We would go further to say that we have to maintain our ability to review what DOE gives us. They told us to this point, I think, that they haven't analyzed for water content. So what we're doing is doing a very narrowly focused look at water content, not systematic, not comprehensive, but just to get an idea of what the water contents might be.

If it turns out that there is an effect or there is high-water content, we would then transmit this information to DOE. We would tell them that we believe it is significant and that you should do a comprehensive investigation related to it.

MR. STEINDLER: Is the converse correct? That is, if you do not find a high-water content, you're going to go away happy?

MR. McCONNELL: We would probably resolve the study plan comment that raises this issue. We would probably do it in consultation with DOE, but since it's a staff comment, we could do it unilaterally.

MR. HINZE: Brit, it's back to you.

MR. HILL: Okay. Again, it gets back to whether or not we support a general working hypothesis or break it down and rigorously defend the scientific basis for these generalizations, and that's what we're trying to get at, something more than just a simplified Vugraph.

MR. FOLAND: One important point which you're making or your fellow speakers today have made is alternative models; that these bullets bring up the idea that one can look at these things with alternative models and play with the parameters that way.

MR. HILL: Yes. I think it's really important for us to remember that one of our missions is to examine a full range of models to not underestimate potential risk and consequence, not whether or not this is the ultimate right model, but that we full considered credible alternative scenarios and hypotheses.

In the interest of time, I'd just like to skip over the last two slides where there is just a general idea of what we can do with a geographic information system. Quite simply, it allows us to display different information, such as the age and general geologic terms, magnetic polarity or where all the samples came from that we're using to construct and develop these different hypothesis.

MR. STEINDLER: Give me a clue how big this system is in any units as long as you define them.

MR. HILL: By the system, do you mean the GIS?

MR. STEINDLER: Yes.

MR. HILL: The GIS is, essentially, running on a Spark-2 desktop computer. It's like a very high-powered 486, but still in the mini computer range. There are versions of this GIS that run exclusively on a desktop computer. They're not as powerful and they are slower, but they have very similar functionality. This isn't something that we have to get Cray time for.

MR. HINZE: Do you have a provision for transmitting that information to DOE in mass?

MR. HILL: I'm not sure if we have that set up. I think we're still working on getting some of the DOE database information and publicly accessible.

MR. HINZE: Is this publicly accessible, going to be publicly accessible for examination or utilization?

MR. HILL: Yes. The thing that's important to remember is we have actually been working on the mechanics of this GIS since about -- one year is about the time we've had on it. Many of these coverages are not complete, nor have they been reviewed completely for accuracy. Essentially, it's not a QA'd, if you will, database.

I will stand in support of what we have up here, but in terms of giving it out for the NRC or the DOE to say this is ultimately what we think is happening at Cima, that's a little bit down the pike, but we're working towards that.

MR. FOLAND: When one puts together this database, how do you QA a factor that you put in?

MR. HILL: Right now, the QA is making sure we can identify where every piece of data has come from, what the original author and the original documents were or where all the data is from, if it's from a thesis, if it's from a State survey.

The other QA procedure involves if we cannot locate a sample spatially, if there's no map, there's no spatial information, it really isn't much use to us in the

GIS. We have to be able to take that sample, put it on a place on the map that makes sense, look at some corroborating information, see whether the analysis itself is reasonable for that kind of region and composition.

MR. FOLAND: Right, but you have no idea, for example, in your Cima field, whether these ages -- I think that's what the numbers are -- are correct.

MR. HILL: The CIMA field, these ages are coming out of two labs, mainly at the USGS. They have appeared in the published literature in many different forms.

MR. FOLAND: I'm sure they're correct, but the principle is anything that gets entered, is there any sort of review on the quality of the information that's being entered?

MR. HILL: I think in a very general way there is. We're outlining whether we can thoroughly trace the numbers, but determining whether these numbers are bad or in valid, that's a very subjective determination.

I think it's not really our place to be qualifying all the data that appears in the geologic literature for the western Great Basin.

I think it's very important, though, that we can go back and say, well, wait a minute, that age isn't right, where did we get it from, find out what the original source was, and modify our database accordingly if contradictory research comes to light, and there have been some examples where we have just left off data because there is contradiction about the age, magnetic polarity, for example, compositions that appear to be very different for the same flow, and in the absence of being able to resolve that by just a typographic error, it's just we're not going to put it in the database.

MR. POMEROY: Let me go back to one question that Ken had. In terms of the availability of this database, is this eventually or currently available to the State and the other interested parties?

MR. HILL: Not currently.

MR. POMEROY: Do you plan to have that at some reasonable time in the future?

MR. HILL: That's not my decision, quite frankly. I think from a technical basis or technical perspective, I see no problem with that, and it's a good direction to move towards. We should be sharing and communicating data, but it's also important to preserve the status of the data whether this is developmental, which it is right now, versus something that we're very comfortable with as being representative of the literature and accurately entered into the database.

MR. POMEROY: I've heard the same argument from the DOE saying that was the reason why they couldn't give data to the NRC, also.

MR. McCONNELL: I think we're just starting to struggle with the applications of the GIS system and also the extent of utilization and the requirements for maintenance, and I think these are questions that management in the end is going to have to address, again, to weigh the benefits versus the cost of maintaining these things.

Certainly, the main database for the site, the licensing database is with DOE. This is just an effort to develop again -- and I'm sure you're tired of hearing it -- our ability to review what DOE provides us, and I would like to give you an example of why it becomes important, and I will use the erosion topical report review as an example.

As you're aware, we have a topical report in for review, and there were a lot of questions about the data that went in to support the conclusions. We've been in the process now probably since at least November and I think even before that of trying to get some of the supporting data, so that the center and our own staff can do some analyses to review the assumptions and conclusions, and it has been a very difficult time. We haven't completely gotten all the data. We haven't gotten an electronic format that makes it easy to use and manipulate. So, because of that, we feel that at least to some level, we're going to have to develop our own independent capability in a geographic information-type system, and that's the basis.

We're not duplicating what DOE is doing with their licensing database.

MR. FOLAND: It sounds to me, Keith, as though this database, in fact, is much more comprehensive in a number of dimensions than what DOE will be doing because it extends far beyond the repository circle of interest.

MR. McCONNELL: That could be.

MR. FOLAND: Right.

MR. McCONNELL: It could be.

MR. FOLAND: So, in order to then build this system, because it's going to change, it's going to change next month because there are new data, there are better data, there are revised data, and to keep the capability of making the assessment for licensing in the future, then this is a commitment that is made now and it's a long-term commitment. That is, building the database has the continuing maintenance fees that really ought to be built in or you don't buy it in the first place.

MR. McCONNELL: Exactly, and I don't think that that's appreciated, and it's probably the technical staff's fault at the management level. I think that it's just beginning. We're beginning to become aware of how significant a resource and financial sink this could be, and I think once the center gets to a point where they think they have a fairly satisfactory database, I think then we need to go to management and say we do need this work and this is the reason why and this is how much it's going to talk, and then specifically identify it within the center's work plans.

It's in the research work plan, but it could become, in essence, a technical assistance activity, where they will be supporting the licensing staff with this GIS capability and, in essence, transferring that capability to our own hardware up at One White Flint.

MR. HILL: I think it's very important to recognize that this GIS was developed as specific parts of the research projects that were developed with NRC research; that it was not created at first as a specific tool solely for the license application review process. It has become clear, though, that it is going to be an integral part and a very important vital part of this process, just because of the huge volume of data that is both in the available literature and that will be forthcoming from the Department of Energy. We've got to have the right sort of framework to evaluate it.

MR. HINZE: Help me out here just a bit, Brit. In terms of the use of this system, in your volcanic systems research program, you're looking at this from a regional standpoint. Are you also planning to use this database, this GIS system as a way of identifying critical area for more intensive study which might include field study?

MR. HILL: Sure.

MR. HINZE: Because all you've talked about at this point is, essentially, library type of activities.

MR. HILL: I'll be getting into some of the specifics of what we can do with it, but, yes, it's critical.

For example, for testing probability models, we can't just apply a simple probability model to the Yucca Mountain Region and have any confidence that it accurately describes a geologic process. We need to go to other areas where the age of volcanoes and locations of volcanoes are well known, to see if our general model is valid within other volcanic fields as well.

A robust probability model should work, really, in a number of fields, sometimes even irregardless of the mantle source.

Let's skip over this one. It just shows migration of volcanism with time. As the last point, let's get into just an example of what you can do with a geographic information system.

We can test hypotheses, and it's more than just library catalog and evaluating whether or not the references are complete. One of the conclusions in the status report was that volcanoes are restricted to low-elevation alluvial basis, not universally, but generally. There's this overall tendency for volcanoes to be at the low elevations.

Yucca Mountain itself is not a low-elevation basin. Therefore, the probability of volcanic disruption is significantly lowered because Yucca Mountain is a topographic high, and I have provided the basis for that from the status report.

So we can test this hypothesis. Our volcanoes are truly restricted to alluvial basins or low elevations in the western Great Basin or basin and range, in general. It can start off by first setting the tone with what's going on in Yucca Mountain itself.

From the crest of Yucca Mountain to the lowest elevation quaternary volcano in the region (Lathrop Wells), we have a total vertical relief of about 670 meters. So, from a very conservative sense, if volcanoes are distributed over 670 meters in elevation, that may not represent a robust topographic barrier.

Where we go around within the quaternary volcanoes in the Yucca Mountain Region, they're distributed over vertical elevations of over 700 meters in difference. So this Yucca Mountain system can really ignore changes in elevation of over or about 700 meters. So that's the first idea that, well, maybe this hypothesis isn't supported by the available data at Yucca Mountain.

We can use the GIS to test this hypothesis in other analogous areas. For example, we can go to the Cima volcanic field in east central California, and we can see at Cima that there's a large number of quaternary volcanoes. These are the contour lines at 250 meters elevation. You can see that the volcanoes at Cima are not restricted down here to the low-elevation alluvial basins or up here on another kind of broad basin, but in an area that's relatively topographically high.

In addition to the overall location of this volcanic field, the change in elevation of the base of these volcanoes ranges over about 450 meters of vertical relief. So, from here on up into the highest areas, it's overcoming about 450 meters. So, again, this 400-, 500-meter range at Cima doesn't seem to be a robust topographic barrier to volcanism.

We can go over, also, to the Big Pine volcanic field, again over in east central California. When you look at Big Pine, very few of the volcanoes, in fact, really only about three are restricted to the center of the Owens Valley in the alluvial basin itself. Most of the volcanoes trend up into the Sierra, Nevada, Mountains, and you look at the change in elevation from the lowest one, Fish Springs, up here into Sawmill Creek and Oak Creek. You're looking at over 800 meters of vertical relief and not just at a single point.

There are three or four dike complexes in Sawmill Creek and Oak Creek and also another volcano isolated on the east side of Owens Valley, up at about 800 meters above the base of the valley floor. So here is another very specific example of how basaltic volcanoes in the western Great Basin can overcome topographic barriers equivalent to the Yucca Mountain site itself.

So a very preliminary conclusion, but a defendable conclusion would be that the hypothesis cannot be supported; that Yucca Mountain proper does not represent a robust topographic barrier to possible future igneous activity, and this is the kind of model that we can develop and test, using the geographic information system because we're going to have the elevations in there. We're going to have ages, vent locations. We can go out and examine these features and quantify this age relationship and elevation relationship.

I am not trying to say that they all erupt this way, but we can certainly look at a distribution or perhaps topographic gradient that can serve as an effective barrier or some sort of a barrier to increased igneous activity.

MR. STEINDLER: What is the source of that hypothesis?

MR. HILL: The source of the hypothesis is on the handout under Basis.

MR. STEINDLER: It came out of Crowe?

MR. HILL: This is out of the preliminary draft status report, and those are the direct quotes, and they are taken within context.

MR. FOLAND: I know this is just your example, but I'm not sure that this is meant when this was written -- I can't remember. It's been months since I've read this thing, but I don't think the idea was that the lavas are simply coming out in places of lower elevation. I think the idea is that the conduits are tectonically controlled, and they're coming out along range front faults, and they're basically then concentrated in the values rather than the uplifted blocks, and I thought that was the basic idea, rather than topography being important. That is, we could have had inverted topography. If we've got the conduits there, we'd still get the volcanoes at higher elevations. Is that not true?

MR. HILL: No. I think it's just what it's saying, not that it's --

MR. POMEROY: What is there in that quote that says something about low elevations? I may be completely ignorant here, but I don't see something that talks about low elevations.

MR. FOLAND: I don't think it was elevation, per se.

MR. HILL: Alluvial basins and the Yucca Mountain is in a range interior. It's at a higher elevation.

MR. POMEROY: Well, that's not what it says here. It says in a range interior. That's certainly true, and, therefore, presumably, it's at a higher elevation, but that's not the argument here, as far as I can see, in this quote, but I'm just taking it out of context.

MR. FOLAND: I am, too.

I think there's another point. I don't think that topographic elevation was the principal point of the basis comment here.

MR. POMEROY: That's right.

MR. HINZE: Part of it was relief. It wasn't topographic elevation.

MR. FOLAND: Well, I think it's tectonic control.

MR. HINZE: Which is exemplified in relief.

MR. FOLAND: Yes.

MR. HILL: You're getting back into the literal statement, the interpretation, and how we're going to effectively evaluate these sorts of statements.

MR. CONNOR: If I can interject for a second, can I encourage you to go back to that original draft because it does talk about elevation in that original draft quite explicitly and at length, and this idea that Yucca Mountain is a topographic barrier has been floating around at meetings, at least the meetings that I've been to. Again, it's just an example.

I understand that most people who work in the region talk about structural and tectonic control, and, certainly, that can also easily be evaluated using this -- well, not easily, but it can be evaluated, in part, using this database as a utility, but, again, here is an example of how you can take a statement made in anybody's report and evaluate it in a geographic information system. That's the main point here. Elevations have been discussed quite a bit in terms of being barriers to volcanism, and these things happen in low-line alluvial basins.

That simply is not supported in this case by even a cursory look at the region, especially the Big Pine map that's in the handout. It can kind of lay that sort of discussion to rest. Certainly those things marching up into the Sierra, Nevada, can lay the elevation issue to rest, and, certainly, the idea that Yucca Mountain itself can be a barrier to volcanism can be laid to rest using -- not laid to rest, but can be evaluated using those sorts of data. That's an example.

The elevation issue comes up quite a bit, and this is a way to say, okay, let's not worry about it.

MR. FOLAND: Right. I mean, as an example, I have no problem with what you're saying, but to take this one step further then, if you wish to test this, you also have things like structural features as part of your GIS that are testable with this.

MR. HILL: Sure. Good Lord, yes. Nobody is proposing that we just use one or two data types, and that's the whole need for having this geographic system, so that we can put things like the vent locations and flow distributions up on the faults. Let's start querying is there a fault density distribution within this area, expand the area out instead of having to have an arbitrary definition of area for a fault zone. Get the distribution functions and qualify these relationships instead of having very subjective criteria.

The point I want to make is that we can qualify these relationships by using a geographic information system, and that's one of the values of having this system.

MS. KOVACH: May I interject here? Linda Kovach.

Ken, to address that, they also are adding into that geophysical datasets as well. It's not just elevation and vent locations and geochemical data. We specifically asked them also to look at the geophysical, and it's correlated very closely with the tectonic database, so that, hopefully, in the end we'll be able to take a look at some of the synergistic or coupled effects.

MR. HINZE: Is there a geographic region specified as part of this database then?

MR. HILL: We identified in the early stages of the volcanic systems project that the western Great Basin region was probably the best analog and the area to focus on. The total extent is going to depend on, again, time and resources, but I think we're really gearing towards the western Great Basin province.

MR. STEINDLER: Having identified a potential application for hypothesis testing using the database, how do you justify not turning over the job of completing that database and expanding it to include other parameters than the ones that are currently in there to the Department of Energy as a requirement for them to show that their hypotheses are viable?

MR. HILL: I'm not sure I can really answer that except from a technical perspective.

MR. STEINDLER: Okay.

MR. HILL: The ability and the necessity to have an independent source of data, I feel that's very critical that we have data that we know where it came from in order to both develop these alternative models that are an integral part of our research effort and also for use as part of the application review.

MR. STEINDLER: I'm a little concerned about the comment about independent source of data because you don't have an independent source of data. You folks are all looking at the same literature and the same uncertainties and unknowns about how good that information is. Unless you actually go out and do your own sampling and then go through the data generation, which I don't sense being a necessary attribute of the information that's put into this, it looks like, very large and probably growing database.

The independence of the data, it seems to me is somewhat a troublesome feature, unless you do not believe that your QA people are doing an adequate oversight job of what the DOE QA program is, which if that's the case, then that's a different story.

MR. HILL: It's not that we are independently generating these data. The importance is in how the data are combined and grouped and how we attach uncertainty to the data.

We are using the same publicly available information that the DOE has. How we combine that and link it to certain things may be very different. For example, at the Cima volcanoes, it's ambiguous at times what samples came from which vents. We know where the flow is. We know where the sample in the flow is, but which volcano did it come from? We're going to have to try to resolve that uncertainty to the best of our ability, and perhaps the DOE will have a different approach or a different insight in which flow represents that vent.

MR. STEINDLER: Is that a function of the transparency of the database?

MR. HILL: I think it's fairly transparent. We're able to get back to the source of the original data. Hopefully, all databases will maintain that kind of integrity to where you can determine where your data are coming from, and you can document the steps that you've created to incorporate and combine these data.

MR. HINZE: Keith, did you want to add something?

MR. McCONNELL: Just to address the first part of your question about giving DOE the information, certainly, we'll make the results of the center's efforts, GIS and otherwise, available to DOE, but, again, we're walking this tightrope of not developing our own database and developing the licensing database for DOE. In essence, the requirements for our database as far as quality assurance are probably less because, basically, what we're trying to do is become knowledgeable enough to tell DOE they need to address the specific issues.

I think had this GIS system been up and running last year, we probably would have been more effective in communicating the concerns that we've tried to express.

Right now, again, a lot of times our comments come across as "what ifs," and they can respond, well, you have no support for this, and rightly so, no support for this concept that you're pushing us and requiring us to take a look at.

So, again, it's only in the context of our review. So we're not going to, I don't believe -- and this would have been my recommendation to management -- we're not going to use this as a mechanism for prodding DOE, but a mechanism for reviewing DOE's work. If DOE then chooses to ask us for information or just basics about the database, we would provide them. In fact, they'll probably come out in center reports, anyway, that are available.

MR. HINZE: Excuse me, Keith. What is the time schedule on this? This has another six months to go? Where are you in the status of this VGIS?

MS. KOVACH: We have another six months to go, and there will be a final report for this. We're at this point talking about the possibility of continuation, but that determination hasn't yet been made.

MR. HINZE: Is the VGIS going to be the major result of this volcanic system?

MS. KOVACH: It's one of the results. There were four tasks initially in this, and it is one of the results. The other will be an evaluation and assessment.

MR. HINZE: John?

MR. GARRICK: Yes.

Have the volcanic scenarios that have been investigated and the subsequent consequence analysis associated with those scenarios provided you with the kind of information that would narrow the scope of the information search that you're have underway?

I suspect that there is a lot of disruptive events that are "no never minds" in terms of consequences. Has the work that's been done so far been helpful in that regard in narrowing the kind of events and, therefore, providing you some insight on where to look for the right analogs? I suspect that there is quite a bit of guidance that could derive from that sort of thing. Has there been a lot of that?

MR. HILL: There has been a lot of that. I think Chuck will address some of this in looking at the preliminary consequence models, the IPA Phase 2 for example, where we're seeing that a certain spectrum of igneous activity has these sort of consequences attached to them, and that from these preliminary models, we can see that it's not at all clear that this is a trivial process. It could have a significant effect in the total release of potential material, and it is directing us towards truly understanding the range of activity that's possible and trying to develop probablistic scenarios that we can use in PA for these different suites or different types of volcanic eruptions.

MR. GARRICK: I guess part of my point is I think there is as much to be gained in giving some attention to the consequences of these different scenarios as there is in giving some attention to trying to quantify the frequency, and you need to push both of those, it seems to me, in order to economize as much as you can, the prioritizing of your research effort and your data-gathering effort.

MR. HILL: That has been the whole emphasis of the research emphasis.

MR. GARRICK: The point being that analysis is generally a lot cheaper than worldwide researching and information-gathering.

MR. HILL: Yes. The worldwide activities we have are very focused towards addressing data that is not otherwise available.

Again, it comes back to the performance question of whether or not our volcanism model is going to be this with maybe five kilometers ash dispersal downrange or something more like this where you've got 500 kilometers downrange, and a very large proportion of the total eruptive volume contained within that ash sheet, and that directly impacts all of the IPA models to date, the volume of event, number of events, mass flow through the system. Really, I want to emphasize that this is what we're moving towards with the research.

It is identifying those areas that have been deemed fairly critical to our understanding of consequences. We're not out just trying to settle some esoteric arguments about whether or not these kind of minerals were found in this system.

MR. STEINDLER: Help me out. If you have a plume of the kind you've shown up here and it goes up 12 kilometers and downstream 500 to 1,000 kilometers and I'm sitting in the repository, do I care?

MR. HILL: Oh, probably not.

MR. STEINDLER: Then why are you saying it?

MR. HILL: If you're sitting in Los Angeles, I think you would.

MR. STEINDLER: I mean, the issue is not Los Angeles. Our issue is I'm sitting on top of some spent fuel element down there, and I'm trying to figure out why I should care.

MR. GARRICK: I'm from Los Angeles, and this wouldn't bother us at all.

[Laughter.]

MR. HILL: What I'm looking at is from a simpler technical perspective about how much material will you fragment and transport into the accessible environment between this model and the one that limits the dispersal to very localized within the area.

MR. STEINDLER: I understand that. I am trying to make the connection between that and something that impinges on the repository. Tell me how that connection is made from either the quantity of stuff you're throwing up or whatever. Someplace there's got to be some connection to the repository.

MR. HILL: Right.

MR. STEINDLER: Tell me what it is.

MR. TRAPP: There is a very direct connection which may not be getting across, but the models of direct disruption through the repository that are proposed by DOE are the first slide that we're showing. It's very low energy where we're not pushing stuff through. So you're dispersing a very low thing. It's all going through the repository in both cases, but in the first cast, it's low volume, low energy, and the second case, it's high volume, high energy.

If I put through 10 times the energy, I'm going to have a lot bigger consequence which is back to the point that was raised before.

MR. STEINDLER: So your entire focus then is on what actually comes up through a repository horizon.

MR. TRAPP: Our total focus is the consequence of these type of events on a repository performance, yes.

MR. STEINDLER: You have some clue as to what the likelihood is of something appearing in I don't know how many acres of repository horizon in comparison to where else it might appear?

MR. HILL: That's what we're working on with the probability models that Chuck will be getting on with.

MR. STEINDLER: I guess I'm still trying to make the connection. Does that probability model have some impact? Is that how some impacted on what kind of eruption you have, whether you've got that kind or the low energy kind?

MR. HILL: That's one of the issues we're working towards is trying to develop the likelihood of different eruptive styles within the western Great Basin and Yucca Mountain Region itself.

MR. STEINDLER: I think I've taken too much of your time in my ignorance, but I'll prod the system again.

MR. HILL: I think one of Chuck's first slides will answer this question more completely than I can in general terms.

MR. HINZE: Before you pass the baton to Chuck, I would like to ask you a question. I know we've beat age dating to death, but you have spent a considerable amount of time evaluating the volcanism age dates in the vicinity. The question that I have is have you identified a research project that will give us a marked improvement in the age dates, and is this a research project that should be carried out by NRC.

MR. HILL: Probably, the best answer to that is it would be site characterization work and technique validation work, both of which, my understanding would be more accurately that DOE's purview to accurately date different volcanoes with more modern techniques and also to demonstrate that the developmental techniques that are being applied at Lathrop Wells have reasonable precisions and accuracies for the age of a process.

MR. HINZE: Multiple techniques applied.

MR. HILL: Multiple techniques that are being used now at Lathrop Wells.

MR. HINZE: So you have not, in your view, found a research program or problem that can be attacked in this area?

MR. HILL: Well, again, I think we could be addressing developing an independent assessment, say, of thermal luminescence dates on reworked alluvial sediments or independent work on cosmogonic isotope production, but, again, it would be the same difficulty that I keep hearing about doing the DOE's job. I think it's even clearer then that the geochronological controversy rests primarily with its application at the site, not in the technique in a global sense.

MR. HINZE: Good. Thank you.

Ken?

MR. FOLAND: Brit, I think in your literature study, you have said Lathrop Wells is 100 plus or minus 50,000 years.

MR. HILL: Yes.

MR. FOLAND: Probably, most people would accept that.

Dr. Steindler is unfortunately gone, but I think that you would get a lot of consensus on that. I think what you told us earlier is that one might try to improve that number, but it's not particularly important. The uncertainty on the young event is not that important to the modeling.

MR. HILL: It's not important from a probability sense, but in developing consequence models, it could be very important to determine the number and timing of eruptions.

MR. FOLAND: Number of eruptions are different, but the actual time of that event is another issue. There are a whole group of things that one could do to look for number of events, not just the timing.

MR. HILL: True.

MR. FOLAND: For all intents and purposes, the timing could be indistinguishable, but there still could be a number of different events. So it's not clear, even if there were something to identify, that it's worth studying in a larger context; that it's important to study. Is that fair to say?

MR. HILL: I think that's a very fair assessment for what is going on at Lathrop Wells.

I don't see us as having an independent research program that is going to add significant results compared to the people that are already attacking this program who are real specialists in some of the developmental techniques. I think the best we can do is get a good way to evaluate these data and have a realistic understanding of the limitations and potential pitfalls in some of these different techniques, so that we understand what the date is representing in terms of the age of the process.

MR. HINZE: Further questions?

[No response.]

MR. HINZE: If not, then Chuck Connor is next, if I understand correctly.

MR. CONNOR: I'm a little worried right now because I've got quite a few handouts and whatnot, and we don't have very much time. With the committee's permission, what I'm going to do is run through this, trying to hit the highlights and anticipating that you'll be asking me some questions when I move a little too fast. Is that appropriate?

MR. HINZE: That's appropriate, but just discuss all the controversial issues.

MR. CONNOR: All the controversial issues. There's no controversy.

[Laughter.]

MR. CONNOR: Brit gave an overview of a lot of the studies we're doing, and what I plan to do now is talk about some of the specific focused research goals and how we're going to address these issues, particularly with regard to testing conceptual numerical models, conceptual and numerical models that are developed in the course of the program either by the DOE or other organizations, and those models that the NRC is eventually going to have to evaluate, and those really, as your questioning indicates, revolve around probability and consequence models for volcanism.

I just would like to start with this picture, which is a CCDF for volcanism based on basically the IPA phase 2 model. It's not my intent to give you the idea that this is the complete performance assessment model. This is an iteration, but I want to use this for illustrative purposes only.

Basically, what we've got is a model for no volcanism, that is, without any disruptive scenarios, and then two models which show disruptive scenarios, but the only disruptive scenario is volcanism. What I've done here is said that the probability of a volcano forming in a 144-square-kilometer area about the repository is equal to 1. It's going to happen.

In order to produce a true CCDF for that single disruptive scenario, you have to multiply that by the probability of that occurrence, and it's just going to shift this curve down. Now, how far does that curve go down? How well do we know where that curve actually plots on this graph? That's the focus of a probability model development.

Right now, different people have different ideas about that. There's actually a fairly broad range, in my opinion, of probability models for volcanism in the Yucca Mountain Region, and I think additional research can be done. It is being done by the center and others to constrain that model better.

Now, what about the consequences? Well, you can see that there's an effect of volcanism on this CCDF. It produces this dog leg. Basically, in some of the runs, the magma, which I said must exist in this 144-square-kilometer area, intersects the repository and causes some normalized relief with some probability.

Different styles of volcanism produce different changes in this CCDF. If we take a current IPA model, the phase 2 model, which is basically an effusive model, you get a dog leg that looks like this. If we take that same model and say, well, gee, these are examples of more explosive volcanism, maybe to be conservative, we should take this into account, I'll just plug in some guesstimates as to the magnitude of these eruptions and what their likely consequences could be. I could produce a change in that CCDF simply because a larger area in the repository is going to be affected by that kind of eruption, and I'll get into the geologic details of that process in a minute.

So our consequence studies are really focused on PA issues and driven by PA issues, basically. What happens to change this curve? I'd like to point out that this is the current EPA standard. If we go to a dosage model rather than the normalized release model, things change.

For example, it's not clear to me why we would only consider 10,000 if we go to a dosage model, and certainly the probabilities of those events go up in that kind of thing. I don't want to limit the scientific or the technical investigations to whether we cross that line. I think that would be needlessly constructing right now. Certainly, if you go to a dosage response, the effect of explosive versus effusive volcanism seems to go up, at least based on preliminary calculations quite substantially.

MR. HINZE: Are those actual calculations, Chuck?

MR. CONNOR: Yes. That is the IPA model. We did those runs, but we just modified the volcano code a little bit to look at a slightly more explosive volcanism, but that's the current IPA model, phase 2 model, I should say. It's not necessarily current anymore.

MR. STEINDLER: If your assumption about probability and that magic 144 square kilometers goes from 1 to some other number, does that whole curve just simply shift?

MR. CONNOR: Yes. That whole curve shifts downward. That's right. Yes. The whole thing moves down to that disruptive scenario. What I would say is that based on these preliminary kind of calculations, it doesn't seem very likely that volcanism by itself would ever disqualify the repository, but I would hasten to add I think a lot more work needs to be done in order to evaluate that more fully, particularly with respect to the consequences, how is waste transported in this kind of system, where to ash blankets go and that sort of thing. It would be very important in a dose base model for which the curve looks quite a bit different than this one.

Let me just give you a quick outline of the topics I would hope to cover, and I'm going to cover these fairly briefly. I want to talk about the current status of some of our consequence studies, particularly with regard to what we can learn about eruption mechanics and how we're using the study of modern monitored eruptions, that is, eruptions that volcanologies have been to and studied, to better understand what eruption mechanics are like in small volume basaltic cinder cones like those in the Yucca Mountain area, how we're going to learn about heat and mass transfer at cooling systems in cooling cinder cones basically with regard to what happens to the hydrologic setting, what happens to geochemical transport when you put a high-temperature volcanic gas through the system or even simply conduct heat away, and what does it actually look like, what does that process look like in a cooling cinder cone.

I will mention briefly some of the conceptual model development and the impact of these consequence models on probability by which I mean really that CCDF I just presented.

The current status of some of our probability studies which involve estimating recurrence rates, there is just a little bit of a controversy about how you do that, and that's because it's a complicated problem. How you can use spatial statistics and spatio temporal statistics to describe vent distribution in the Yucca Mountain Region, this can give you a guide as to which probability models will more likely describe that sort of distribution than others.

I want to talk about two probability models that we're developing at the center. I don't know if I'm going to get to these in detail, but the nonhomogeneous Poisson model and the Markov model and how those are different than, say, current DOE models and other models out there

I would like to try to close with some words about getting to the geologic basis for some of these models and how we can use a lot of the information in that GIS, for example, to really better understand this probability issue.

MR. HINZE: Chuck, let me ask a question related to the reoccurrence rate.

MR. CONNOR: Yes.

MR. HINZE: Do we have any area or any study of a comparable area where there have been reoccurrence rates determined?

MR. CONNOR: Well, we're working on that, and there are several studies that have been done using parts of datasets or subsets of data. For instance, Charlie Bacon did a lot of work in the Coso volcanic field about 10 years ago on his estimates of recurrence rates. Some work has been done in the Stanker plain on recurrence rates, and we're working to use datasets compiled at other areas to estimate recurrence rates in fields that have gone through this waxy and steady and waning stage, and they're definitely waned. So we ought to test some of these models.

It's a pretty complicated issue. What I've been discovering is when you take a lot of the methods that have been applied to the Yucca Mountain Region to estimate recurrence rates and you really study some of those assumptions, you have to get back to the geologic basis pretty fast. Otherwise, you can massage the recurrence rate in different directions.

Yes, we are looking at it. Some studies have been done in a couple areas in the Coso volcanic field, in particular, where Bacon seemed to have a lot of success with his approach. Actually, he based that on about six volcanic eruptions. So it's a pretty limited application.

We're working on the recurrence rates and testing those using data from the GIS and elsewhere.

MR. HINZE: Testing them against Coso and so forth?

MR. CONNOR: Yes.

I wanted to go through this relatively quickly. This is a fuzzy picture because there is so much ash in the atmosphere here. This is an example of an erupting cinder cone, and basically, the lighting is pretty rough, but basically, here is the top of the cinder cone and this ash column is going up about 8 kilometers. This picture was taken 9 kilometers away. It's Cerro Negro volcano in Nicaragua. It is a cinder cone that was first formed in 1830, and this is the 1992 eruption.

I went down there at the request of the Nicaraguan government to try to help them assess the impact of this activity on the local popula[illegible] About 28,000 people were evacuated as a result of this. I think it simply illustrates that, yes, this type of very small volume basaltic eruption can be quite explosiv[illegible] [illegible]d can influence a large area and does have consequences f[illegible] [illegible]he people living around it and will likely, if it were to occur, impact repository performance as well.

Just really quickly, that volcano is located here in Nicaragua. I will let you look at [illegible]t, at your leisure.

One of the huge advantages of looking at that kind of eruption is we can measure things in a very simple and pragmatic way. We can gather data that otherwise are not attainable or have to be inferred, and this is a very good example of that kind of data.

This is the ash blanket associated with the Cerro Negro eruption from 1992. Several other ash blankets have been mapped from eruptions in '68 and whatnot, and they're fairly similar.

This is an isopaque map. That's the 10-centimeter isopaque. That means the ash layer is thicker in this region, then 10 centimeters thicker in this region, and then 100 centimeters and so no. The 1-centimeter isopaque extends nearly to the Pacific Ocean, something like 35, 40 kilometers in this case. You can get a really good handle on that.

How do we use that kind of data? One part of PA models for volcanism is assessing the dispersion of ash or the likely dispersion of radionuclides in the event of disruption, and we can test those models using these kinds of data.

Here is an example of an eruption which occurred over some period of time. Here is the resulting ash blanket, and we can test more specific models; for example, models of eruption dynamics for small volume basaltic eruptions. We can look at this kind of data and discuss it in a very pragmatic way.

This next overhead illustrates some of the observations that are easy to make in an erupting cinder cone: an observed column height of 7 to 8 kilometers during an 18-hour period of activity, a lower column height during a second phase of activity, 3-1/2 to 4 kilometers. We can observe that this volcano had a sustained ash column. The strombolian model does not apply in this case. In fact, it has more of the characteristics of a small palinean eruption as a sustained volcanic eruption. Then it is often supposed to exist at some cinder cones.

We know about ash accumulation rates. That's very useful information if you're going to try to test dispersion models in a quantitative sense or semi-quantitative sense. We know about the total ash volume.

I want to make the point that this information just cannot be gleaned using traditional physical volcanological techniques from the western Great Basin because these ash blankets disappear really fast. They're easily eroded. In fact, if you go to a place like the Rudio volcano which erupted in 1750, you see this hugely dissected and removed ash blanket, just remnants of this kind of thing around, and certainly in a time scale of a thousand years, those ash blankets are gone. They don't persist in the geologic environment.

From this kind of data, you can infer things like a mass flow rate from the volcano, 300 to 500 cubic meters per second, and that's data that's very useful in evaluating eruption in the models.

You got a question.

MR. FOLAND: Is this work that you've done part of the research of the center or somebody from the literature?

MR. CONNOR: Actually, as I said, I worked on this. I started working on this in 1992. To a certain extent, it's serendipity, but, also, the reason I work at the center and the reason they're interested in me is because this kind of work fits right into the program. So I'm continuing this kind of work as part of the field volcanism project, and it's not in the literature yet other than a couple of AGU abstracts I presented, but I hope to get it there relatively soon.

We're doing things like working up on the reality of the magma and that sort of thing in order to better constrain an eruption dynamics model.

Here is a real simple example of an eruption dynamics model and how you can use these data to test an eruption dynamics model. Certainly, a lot of the work that Greg Valentine has been doing and others in the field go well beyond this. I just wanted to show you a simple sort of example.

It's possible using estimates for these parameters based on observations of the volcano to learn about the steady thermal energy release and eruption using a technique that was developed by Lionel Wilson, and it turns out that the Q of that steady thermal energy release might be on the order of 10 to the 12th watts.

Wilson discovered that for these types of eruptions, he can then calculate the column height based on Q, and he comes up with a column height of 7-1/2 to 9 kilometers. In other words, it's possible to take this set of observations, plug them through, and calculate a column height and compare that to an observed column height which turns out to be about the same. Within the uncertainty of those variables, it's essentially the same.

You could say, gee, I know something now I didn't know before. This eruption is well-described as a sustained energy release. It's a sustained column and has characteristics very different than, say, a strombolian eruption which would be an instantaneous energy release.

That kind of approach can give you a lot of confidence in a model or it can point out problems in a model, and I just don't see another way to do that in such a defendable way. These are the observations. This is what the model is telling us, and we can test that model in a very straightforward approach.

Just to summarize very quickly, how is that information used? Well, it can be used for a direct modification of PA models. If we say that, well, ash dispersion is really different than we thought it was before, let's just put that as a probability distribution into the PA model.

It's also possible to get right back to the western Great Basin and say there are some things that I can measure at these other volcanoes where I've seen what's happened, and there are things that I can measure at western

Great Basin volcanoes as well.

The nice parameters are basically gone. You can't just say this was the column height of Lathrop Wells or this was the size of the ash blanket at Lathrop Wells. That information is not preserved in the geologic record, but you can look at the volatile content, and Brit talked about that quite a bit. We plan to do that kind of comparison. You can look at the mineral assemblages. You can look at the size distribution and compare in a very systematic way.

Now, it may turn out that the magma was substantively different at Lathrop Wells than it was at any historically active cinder cone, but we can make that comparison using the best tools we have available and come to some conclusion about that. So, at the very least, looking at these modern analogs are going to help us test numerical models which, I guess, is that third bullet, using well constrained observations, and, hopefully, we'll be able to get back to a direct comparison with what's been happening in the western Great Basin as well, and that's kind of exciting.

A lot of these techniques are pretty much modern volcanology, and we're working hard to acquire that data. It's something we're working on over the next couple of years probably, but I think it's going to produce a very defendable means of testing eruption dynamics models, and this gets back a little bit. This is a complicated graph, and I don't want to talk too much about it, but this gets back to what effect does this have on the repository itself.

Here is the depth from the surface in meters. So depth is going that way. You might want to look at the graph like that almost, just to say this is depth going down here, and this is the gas fraction. 100 percent is up here, and 0 percent is down there. That is, the gas fraction is the magma that sends through the crust. Volatiles are absolved from that magma, just like a bottle of soda pop, the bubbles are absolved, and that's important. The common wisdom, frankly, is that reaches some percentage, about 75 percent, where the magma fragments, and the characteristics of flow in that system become very different.

The magma becomes quite erosive at that level and can pluck zenalists and waste containers out of the wall relatively easily and move through that system. So you might want to know about this depth of fragmentation.

One of the things that controls the depth of fragmentation is the percentage of water in the initial magma. As the magma rises with 1 percent water originally in it, it begins to absolve that water and other gasses, too. It begins to absolve that, absolve that, absolve that, absolve that until, in this case, it reaches a fragmentation depth at about here.

I need to get back to that in more detail in a second, why that kink exists. Basically, we say at that point the eruption, the magma becomes a little bit more erosive. That 3 percent curve reaches that fragmentation level at a greater depth.

So, if we can get back to the initial magma concentration, maybe we can use this model and even more elaborate models to try to constrain the depth of that fragmentation.

Now, what is curious about the repository is we changed the pressure by putting the repository in there. What I've done here is I've assumed that at repository depths, you're going to have a pressure condition, at least initially, which might be in your atmospheric. If we go to a repository that collapses in on itself, that's going to change through time, but always, initially, there's that big change in pressure. So any magma reaching the repository is going to have that kink in it at the repository horizon where the pressure suddenly drops very rapidly, and I just got the change in pressure from our rock mechanics people about what that would look like for the repository horizon.

So, anyway, getting from that data, collected in an active eruptive cinder cone, comparing that with parameters that we can gather from the western Great Basin, and putting that together in a model can test these kinds of ideas, which are the ideas that people talk about in this program, and certainly, the DOE and others are working hard to develop eruption dynamics models, and we're working hard to gather the kind of information that can be used to test those models in a way that's convincing to us.

MR. STEINDLER: If you carry that just a little further, you've got this erosive material that's now running past my canister that I happen to be sitting on. Is the intent of this model to have it destroy the canister and throw out to the accessible environment the contents thereof?

MR. CONNOR: It's not the intent of the model. What we're looking at is trying to figure out what the mass flow rate would be through the repository at that point, and that will involve some models in rock mechanics and such that we just are not at the stage of developing yet, but let me give you an example.

There was some question in some parts of the program, some statements which suggested that a stokes model might be important here. That is, so what if a magma comes through a repository horizon. Any canister is pretty dense. These things are pretty dense. Maybe it will just sink by stokes flow, never reach the surface.

Well, in order to test that kind of model, we need to know something about the mass flow rate and the likely eruption velocities in the repository at the repository horizon in order to know what's going to happen to that canister.

Now, the detail you're looking for there is definitely a direction to go in, and I would say we better get the eruption mechanics model together first because otherwise we're going to have a hard time justifying the detailed model and the kind of thing you're talking about would probably require, other than a back-of-the-envelope calculation which would say, yes, the canister would go up and sail ballistically out for 2 kilometers.

I'd like to point out another good reason to look at these active cinder cones. You can go to even Sleeping Beaut's volcano and walk out from the base of the cone and see canister-size blocks that have been thrown out 2 kilometers. Well, I think at the Sleeping Beaut's, it might be less than that, but these things do, rocks of that size, not that density, but of that mass, are ejected from these volcanos. So we somehow have to learn about the likelihood of that kind of event and the likely behavior of the likely mechanics of the eruption before we can really get back to the detail you're looking for there.

That's definitely the way to go. The end gain is to say this is what's going to happen to a canister under these circumstances, but, wow, let's learn about the eruption mechanics first. Let's look at the likely effusion rates, the stress existing at the repository horizon as the result of a dike injection and that sort of thing before we get back to that question specifically.

MR. GARRICK: Just to pick on that a little bit, after all, when we talk about consequences, we are talking about getting it down to that level of detail.

MR. CONNOR: I agree.

MR. GARRICK: It seems to me that you're always confronted with how much you nail down the science or the mechanics of the eruption and the pathways that are involved, et cetera. You're always trying to weight that off or balance that off with, well, is there a way I could just do a first approximation analysis and hold up a while and take a look, a little deeper look at the consequence question.

MR. CONNOR: Right.

MR. GARRICK: I think there is a theme I'm hearing here of concern of the committee of scoping the effort here, and the reason I'm butting in like this is that you seem to be suggesting that we need to do a lot more volcanology work first before we do that, and I guess I'm challenging that.

MR. CONNOR: I agree with that statement, and I want to point out that, in my opinion, this was a scopine exercise, and we have done back-of-the-envelope calculations with regard to areas of disruption of repository for a given explosivity.

In a real sense, I think we've made the back-of-the-envelope calculation. What this kind of thing assumes is that if this canister is in that fragmentation envelope, it's going to go. It's going to make it to the surface.

I would be hard-pressed to envision an alternative scenario given the dynamics that are known to exist in volcanic eruptions. I think maybe Ken will want to get together a panel of experts and ask them if they're willing to bet their monthly salary, but I think a group of volcanologists would come to the conclusion that, given a mass flow rate at the repository level and intersecting a canister, that that canister will be dispersed.

I think in detail, that involves some assumptions. We're trying to get into the assumption testing mode here by looking at these things in detail.

Also, I think there is a range of explosive activity which we need to account for, and not all western Great Basin volcanoes are going to look like Cerro Negro, and I don't think they are, but how many of them are. In fact, if you go to Parikatine volcano, for example, which had similar kinds of explosive activity and walk around the ccne, it looks awfully glutinated in places. It looks like a really low-energy event. So you go through this range of activity at a single cone as well.

Those are the kinds of issues we need to address in some detail in order to get beyond that, this dog leg here.

I think there was some back-of-the-envelope stuff that we have done to address that in a general way, and getting beyond that will take some work.

MR. HILL: A quick point here. This is Brit Hill again.

It's important to remember that at Lathrop Wells, you can go up into the cinder cone and see fragments of the underlying wall rock that are this big down into this size range commonly. So these kind of volcanoes have the ability to fracture, entrain, and erupt large pieces of coherent wall rock, and that's the underlying assumption right now in the PA models is that the canisters will to the first approximation respond to this energy release pattern in the same way that wall rock has.

MR. HINZE: Are you ceratin that they're not fractured in the country rock?

MR. HILL: Not certain at all except that the fracture surfaces are very fresh, and they do not have any sort of secondary mineralization along them that would be indicative of a longer-scale fracture, something that's been there for a bit of time.

The whole area is faulted, but you can look at dikes as well in a number of other areas and see that it's not a piece of wall rock that's being entrained. Rather, the surrounding coherent wall rock is being fragmented by the intrusive activity.

MR. CONNOR: A first approximation, and we're talking about a first approximation in this case, if I can take you to a block that has the mass of a canister and it's lying a kilometer away from the volcano, I'd say that probably the magma has the capability of moving a canister. I think at this point that's not a bad first approximately and indicate that we really need to know what controls that range of explosivity and how it operates and make some more educated guesses than we can now about how it's likely to operate in the future at Yucca Mountain.

There's a pervasive idea -- I could talk about this for an hour.

MR. POMEROY: Let me ask you a question. Maybe I don't understand quite what you're doing. You're basically looking at -- go back to the question of just eruptive mechanics at this point.

MR. CONNOR: Sure.

MR. POMEROY: You're basically looking at different environments from the viewpoint of trying to establish the range of uncertainty at Yucca Mountain. Is that a fair statement? Or, are you trying to establish the eruptive mechanics of Yucca Mountain, of potential volcanic activity in the area?

MR. CONNOR: That's a real interesting question because it gets back to the site characterization. You can't only learn about potential future activity from site characterization, in this case, because nobody saw these things erupt, and maybe of us volcanologists, we just don't have the techniques to evaluate that range of activity encompassed by those volcanoes.

So we need to look at the best examples of this style of volcanism that we've got and look at the range of activity.

The slides that Brit showed of Tolbachik are a really good example. There is a group of five cinder cones that show the spectrum of eruptive activity. Can the models that are being developed to look into eruption mechanics encompass that range of activity, given the parameters that we can measure? Is there a spectrum in mineral assemblage, volatile content of vesicle size distribution that those volcanoes which encompasses the range we see at Yucca Mountain or not?

We're not going to wind up with this is the way volcanism is going to be in the future at Yucca Mountain.

We're going to wind up with an idea of a spectrum of activity, and I would hope we could make a good educated guess as to, say, a probability density function which would illustrate the mode and two standard deviations of explosivity and that kind of thing in some way, but I think there's enough ambiguity and enough discussion in the literature for example about these kinds of eruptions that we need to look at the mechanics a little bit carefully right now and talk about what parameters we really care about in terms of controlling that explosivity.

I think we have a pretty good shot of getting there not only from our work, but also from other work that's ongoing by other groups to get a handle on that kind of model.

MR. POMEROY: So, to get to that probability distribution function, do you see a time frame of 2 years, 10 years, or 20 years?

MR. CONNOR: Everybody tells me I'm a little too optimistic. I think we're going to have the data on these parameters in two years. I think that certainly there are eruption mechanic models out there now that we can test right away with that data, and it may be that some alternative models need to be developed, maybe not. Let's give it three to four years on that.

Then, after that, I think getting to the probability density function, assuming the GIS is with us and moving and assuming that every worker on this problem has been looking at a glutination and dispersion and zenalist, and that dataset just grows and grows. We can resolve this on the order of something like 5 years, maybe, just a shot in the dark to come up with a probability density function appropriate for a PA model.

Now, what we're doing right off the bat is ni the phase 3 PA trying to estimate a probability density function knowing what we know now. There's no reason not to do that, and maybe we'll get to the point before then that we can say, gee, this is good enough. We've got it wired.

MR. POMEROY: Thank you.

MR. CONNOR: I'd also like to talk about cooling cinder cones and point out a few things about cooling cinder cones. One important aspect of this problem is that it hasn't really been addressed in anybody's current PA model. It may be important to this kind of thing.

Volcanic degassing cinder cones is a long-term process. I was at the Rudio volcano three weeks ago, this one that erupted 200 years ago. It has 125-degree C fumaroles. Gas is coming out of the grown at 125 C. At Parikatine volcano, they are 220, 50 years after the eruption. At Cerro Negro volcano, they're in excess of 350, 400 degrees C following these eruptions. So it's a long-term process, and you can probably influence a larger area than is directly affected by volcanic disruption. I will get into this in a minute.

That is important because volcanic gasses and alteration in the hydrologic environment that might result form this heat and mass transport processes are going to change rates of transport in the geologic environment, the rates of transport of radionuclides, perhaps. Certainly, the rate of transported water in the system is affected by this process. There could conceivably be accelerated corrosion of the waste package and change in the mechanical strengths of the rocks as well.

Here is an example of this degassing in the crater of Cerro Negro volcano. You can see these volcanic gasses escaping over a broad area within the cone itself, an alteration of the salts in that crater as a result of that process.

This is Parikatine volcano. It last erupted about 40 years ago. It erupted for 10 years between 1943 and 1952. It seems a little bit dark, but over a broad range and the area on the flanks of the cone and actually extending off the cone for about 300 meters, there is a lot of degassing going on. Most of those gasses are composed of groundwater which has moved towards this system, been heated up, and is being released into the atmosphere.

Over a very broad area, if you walk along the rim of the crater, you'll see the same thing. Down on the other side, you se the same thing. Well, Parikatine sits pretty far above the water table in Mexico. It's definitely not as dry as Yucca Mountain, but it sits well above the water table, and this process has been going on for an awful long time, years and years and years. Well, how does that kind of transport impact the repository if this eruption occurred near the repository?

What do I mean by near? Let's say within several hundred meters or possibly out to a kilometer, that kind of thing. How does that change or affect repository performance without necessarily having direct disruption. Of course, you could couple direct disruption with that process.

Here is an example of a basaltic lava flow at Parikatine with a fumarole. In this particular case, this fumarole is quite dry. It's very hot, and it's dry. It's mostly moving air through this system. At the surface, that temperature is about 220 degrees C. This whole area is surrounded by lower-temperature fumaroles in which there's essentially a vaporization zone surrounding these fumaroles, and this area has looked exactly like this. I first went there in 1983, and at that time, it was 400 degrees C. It's been cooling off since that time.

How do we get a handle on this? Well, one way to do it is to put some instrumentation in these fumaroles and learn about the flow out of those fumaroles and the temperatures of the fumaroles and that sort of thing. Another way to do it is to do surveys around these fumaroles to look at diffused degassing, how much CO_2 has come out of the ground with distance from the volcano, how much helium is coming out of the ground, other geochemical parameters.

Mercury can be used. Radon can be used. We did a preliminary survey here two weeks ago to look at the aerial extent of degassing associated with this system, what area is geochemically perturbed about this volcano by the flow of these fluids. Is there a magmatic component in this case, 40 years after the eruption, or are we looking at deeply circulating groundwaters, or are we looking at shallowly circulating groundwaters? That kind of study can address those questions in a fairly simple way.

MR. HINZE: These data are not available in the literature then, Chuck?

MR. CONNOR: No. Cinder cones are really the poor stepson of volcanology. In volcanology in general, particularly this kind of volcanology, you have a lot of work focused on big, active, dangerous strata volcanoes. That kind of data are available from several strata volcanoes, Mount Aetna, that kind of thing, but nobody's really looked at these small systems and looked at degassing around these small systems in a very systematic way.

Again, I'd point out that is a lot of field effort and that kind of thing to gather these data, but it's not exactly a huge task to gather those kinds of data, and I think they in a very direct way constrain models, what does flow actually look like around a cinder cone and how does that flow pattern change with time. It seems like a fairly simple approach to addressing these kinds of issues.

Here I just summarized what the studies of this kind of degassing involved. You can certainly look at the chemistry temperature and mass flow of gasses. We're going to look at the duration of a mass transfer by looking at cinder cones that have erupted during periods of time in the past, historically, and the aerial extent of that degassing, what area is affected by that kind of process, and it leads to some model development and integration with PA.

Here is a real basic overly simplified picture, for sure, of what this whole process might look like. Definitely, the areas that every cinder cone have been to where there's forced convection through fractures, and that endures for some period of time, gasses flowing up through these fractures. They tend to be near the cone itself, that kind of forced convected degassing, and that's certainly where you get the most pervasive kind of alteration.

There's also an area that's affected by diffused degassing, not only magmatic gasses, but also groundwater. Groundwater is going to move toward this thing. It's going to be heat sink because it vaporizes groundwater. That produces that sink, and that water is moving up and probably reaches some condensation level and that sort of thing.

We plan to use field data to constrain that model and get a little fancy with it, using some of the EQ-6 codes and the V codes developed for the repository and other hydrothermal systems.

That's an example of a real simplified kind of solution. Here is a boundary value solution for degassing, and we're just saying that there's some kind of a source down here, and there's groundwater flow into the system.

This pattern here represents temperature. These lines represent flow paths. What area is affected by flow paths? How does flow change out here as a result of this thing being down here? I think that using codes that are already developed in the community and coupling that with field observations is really going to have a much better idea of the area affected by volcanism not only by direct disruption, but also by indirect effects, and, of course, that's important because the area affected by these indirect effects is likely to be larger than the area affected by direct disruption, based on preliminary observations.

Really, quickly, here is a map of Cerro Negro where we mapped mercury and other distributions, geochemical distributions in September. It's the concentration in mercury in parts per billion, and you can see there are large numbers here, 4,000, 2,000, 1,600 parts per billion along the fracture zone. That corresponds pretty nicely with this forced convection model. At that time, these fumaroles were inaccessible down here. I showed you a picture of that a minute ago.

Over here, we have a sample relatively close to the cone base in this case, going out to about 800 meters from the vent itself. Some of them are low, 80, 33, 28. That's only about 10 times normal background. Some of them are quite high, getting up towards 1,000 parts per billion. That's two or three orders of magnitude beyond normal background, and I think indicates an area of some diffused degassing and convective upwelling beneath the volcano.

Over here on this side of the volcano, we get fairly low, normal kinds of numbers. I suppose if we go outside and this building is not built on some kind of a waste site, then we would get numbers of four parts per billion here, too. So it's sort of a normal kind of value, and I think what's happening here in detail is the lava flows themselves are actually sealing off the system. Whereas, on this side, there aren't any really young lava flows in the system. It's relatively permeable.

How is that information used?

MR. HINZE: Chuck, no matter how interesting this is to Ken and a few of the rest of us --

MR. CONNOR: I know. We're late.

MR. HINZE: -- I think we're going to have to terminate this in 10 minutes. So I will take you at your word that you can focus on what you consider to be the more critical items.

MR. CONNOR: Yes. Okay. So you get the idea of what I'm doing with this degassing.

I'd also like to talk for 10 minutes -- sorry it's so late -- about probability models. I'd like to point out that there's some important criteria in the probability models. I think you will be interested in this.

One, models need to account for the observed spacial and temporal distributions in cinder cone volcanism. There has to be a physical basis for parameter selection in models that require parameter selection.

So, for example, if you're going to look at the mean position of cinder cones, then you have to somehow estimate that from geologic data, and the models have to be consistent with geologic and geophysical information to the extent we can do that.

There were a lot of questions about the status reports. Earlier was a review of the status report I would just like to point out that it's possible to look at cinder cone distributions in a very pragmatic and statistical way. It's not very difficult.

We looked at cinder cones in the Yucca Mountain Region and applied three well-known and often-used statistics to decide whether cinder cones in the Yucca Mountain Region have a homogenous or nonhomogeneous distribution. It turns out with 99 percent confidence, cinder cones cluster in the Yucca Mountain Region. That's common. I think every cinder cone field where that's been studied in a very systematic way, these clusters have been identified. They seem to be a fairly fundamental geologic aspect of cinder cone volcanism.

Differences in the ages of these volcanoes. Well, volcanoes that are close to each other tend to be the same age -- not the same age, but closer in age than cinder cones that are far apart. So there's a spatial and temporal clustering of these volcanoes.

What does that mean? It means that if you're going to look at recurrence rates, the recurrence rate must vary through the region. The recurrence rate is not the same in the middle of Crater Flat as it is 50 kilometers from Crater Flat. It's different. So we get a handle on that difference.

Second, the homogeneous model cannot encompass that in any realistic way, and that's a problem because these homogeneous models are going to overestimate probability in some parts of the region. That is, if you're far from the quaternary volcanoes and you're going to underestimate the probability closer to quaternary volcanoes. It averages that over the area you've studied. Whereas, nonhomogeneous models avoid that kind of problem.

I'm not going to talk about this in detail. In fact, there's a paper, I think, most of you have which summarized the actual mathematical techniques that we've used to estimate the recurrence rate and to calculate the probability. This has been the source of some discussion.

What effect does the age distribution have on probability models? Here I'm using a near neighbor method. We can use other parameters, but, basically, this is the range of quaternary recurrence rates estimated for the region. It doesn't encompass all the recurrence rates. Some are very low. Some are very high. I think these are the most discussed in the literature.

If we run the model for mean volcano ages, as we know them now, you get this curve which would indicate a probability of disruption in this region, but if we say, gee, we probably made some biased systematic error in this one parameter and we use, say, 800,000 years instead of 1.2

million years for the Crater Flat volcanoes, the curve has shifted, as illustrated here, or if the volcanoes turn out to be older, it's shifted here. So that bracket encompasses the influence of our uncertainty in the geochronologic information for models of disruption using this nonhomogeneous Poisson probability model. So it's possible to test these things in a fairly systematic way.

MR. POMEROY: And that's about a factor of 2 or 3 times 10 to the minus 4?

MR. CONNOR: Yes. There is a variation of a factor of 3 times 10 to the minus 4, 1 to 3 times 10 to the minus 4. Actually, the range is larger than that, but if you toss out a couple extreme examples, it comes down.

You can do the same thing with area terms. For example, if you have a hot small repository or a cold big repository, those area terms change, those affect the likelihood of disruption due to magmatism as well.

You can finally plot a probability map using nonhomogeneous Poisson methods. This is contour in the probability of disruption of one repository area in 10,000 years, and that's a logarithmic scale. So this minus 4 corresponds to 1 in 10,000 and 10,000 years. What this map would indicate that the probability of that occurring is higher in this region than the center for one repository area and less further away.

This really accounts for a fundamental feature of volcanism. That is, these things cluster, and in this case, in the Crater Flat Region, and the young volcanoes tend to be clustered in this region as well. In fact, volcanism has just persisted in this region for the longest period of time.

This model can account for that type of variation. Of course, if you choose a different recurrence rate, then that graph can shift slightly. This is choosing a lower recurrence rate, and we can, in fact, get that probability at Yucca Mountain down below 1 in 10,000 and 10,000 years if we choose a recurrence rate. This is three volcanoes per million years which would be quite low for the region in that case.

So I've got a slide here summarizing many of the things we've already talked about, about this range of calculations. There's no reason to restrict this analysis to a single probability model. This is a relatively new game in volcanology, in particularly, and it's important to look at a range of models. They're relatively easy to develop.

You can look at a spatial temporal mark-off model which basically has a whole set of assumptions in here. I don't necessarily agree with all these assumptions, but let's just look at what happens with the model. The location of the most recent eruption, that is, the one that happened most recently, most influences the position of likely future eruptions rather than older events. The time since the last eruption tends toward a homogenous model based on the diffusion equation, which is inherent in mark-off process models. That is, if volcanism is occurring at a rapid recurrence rate, then things are going to tend to be concentrated in an area. If there's a long hiatus between volcanic events, the probability surface tends to flatten out, and you don't know the position of future volcanism too well.

There's a little bit of math on the next two slides which formalize the development, and you wind up with pictures that look like this, using the spatial temporal mark-off model. This is the probability that if volcanism were to occur, it would occur in this 1-by-1-square-kilometer area. So it doesn't define the probability of magmatic disruption or anything like this. This is just looking at an aerial term.

Here what it said is if in this cluster, the southwest little cone is the most recent event -- I just sort of chose that out of this group of volcanoes -- then how well does this model predict the position of Lathrop Wells? So Lathrop Wells isn't there yet, and it says that if Lathrop Wells is 100,000 years old, just for example, then the most probable position of volcanism would actually have shifted a little bit to the southwest, and the reason for that shift is that aerially there is a regional shift from in this direction through time adn the region, but because there's such a long period of time, something like a million years between the eruption of southwest little cone and Lathrop Wells, the probability envelope increases.

We know with less certainty, and you can judge for yourself whether Lathrop Wells is closer or far from that bull's eye.

Then, if we do it for the present, we say, okay, Lathrop Wells happened 100,000 years ago. Where is the most likely position of future volcanism in the region? Again, you get this same story developing, which says that volcanism is most likely in this region. These numbers are a little bit higher because I'm using this diffusion model, and Lathrop Wells is relatively young. The things diffuse outward through time, and the probability, in general, goes down in any one spot, close to the center of this bull's eye.

Again, here is an alternative model which says that, yes, there are some spatial patterns in this volcanism, and if we take into account those spatial patterns, it would tend to indicate a more likely event in the future in this region. I think that accounts well for some of the real basic geologic reason we have here, which is the geochronology and the distribution of events. It doesn't take into account many other aspects of the problem, like this idea of structural control on magmatism and that sort of thing.

Those, eventually, are going to have to either be built into a model like this in a formal way or in a semi-quantitative or informal way, but we can test these models. We can use them. It turns out they come up differently, and it's important to explore that aspect of the problem.

You guys are very patient.

So I have some summary slides that I'll let you read.

MR. HINZE: Amazing job. You did it in 10 minutes, and we thank you very much.

MR. CONNOR: Sure.

MR. HINZE: Our ears are not too tired.

Questions for Dr. Connor?

MR. NELSON: I'll try to keep it as brief as possible. My name is Steve Nelson. I'm with Woodward Clyde Federal Services.

I'd like to ask one question and then make three or four really brief comments because I know we're all hungry. I speak for myself, anyway.

MR. CONNOR: That's my fault, not yours.

MR. NELSON: Would either you or Brit like to give an estimate of the sort of water you think is reasonable for Crater Flat?

MR. CONNOR: Brit stood up.

MR. HILL: In excess of 2 weight percent based on the available data.

MR. NELSON: I'll go to my brief comments, and these reflect my personal professional opinion. First of all, I think that arc magmatism is an extremely poor analog. I couldn't disagree with you more, Brit, on your statement.

I've done a review of water contents in magma, about 150 analysis I've been able to put together so far, and the only types of basalts that have water in excess of 2 weight percent from what's available in the literature are arc basalts. I, again, would reiterate, we're not dealing with an arc system here.

MR. HILL: Were you examining basaltic magmas only?

MR. NELSON: Basaltic magmas.

With respect to geochronology, really briefly, since that's one area of my background, in particular, I think that we need to not have unrealistic expectations on how well we're going to be able to do with the geochronology of some of these young basalts, and that includes some of the clean techniques that you alluded to.

A basalt that's 1 or 2 percent radiogenic is going to be 1 or 2 percent radiogenic whether you put it in a brand-new mass spectrometer or one that's 20 years old. You may be able to deal with system blanks and things like that, but I don't want to get too technical.

I think that the western Great Basin volcanic province is subjective. I have a lot of admiration for Godfrey Fitton, but these designations are subjective designations.

I would also suggest that maybe you might want to look at as an analog for the effect of alteration of the wall rock someplace like the Santa Fell Swells, the dikes and sills out there, which probably represent a few hundred feet depth of the volcanic flows and cinder cones eroded.

What you see is quite striking. The hydrothermal effects extend on the order of a centimeter to maybe just a few meters. I think bringing in analogy of arc volcanoes is not appropriate.

MR. HILL: I, again, would disagree with that. This is Brit Hill. I would welcome the opportunity to discuss the basis for that disagreement.

MR. HINZE: That's the kind of disagreement that I think we can expect to see among geoscientists, and we're not going to solve that problem here.

MR. STEINDLER: That was only two.

MR. HINZE: That was only two, right.

I would like to ask a more general question, if I may, and that is I want to be certain that I understand what's going on in the center in terms of volcanism research. What we've heard today is that we have this volcanic systems in the basin and range which is focused around GIS and the analysis and the interpretation of that analysis, and then we also have the field volcanism analog.

What else is there? Is there anything else that's there at the center in terms of volcanism research? What is on the immediate agenda for additional activities? We've seen in 1406 that there are some plans for '94. I realize that 1406 is a draft document, but can we be brought up to date on this?

MR. CONNOR: Yes. I think one of the things, for example, we didn't hit on several of the task-oriented things we're doing. For example, we're looking at dike fault interaction in a fairly systematic way as well, using areas in the western Great Basin, and also getting into the literature on the dike propagation and rock mechanics.

It's going to address the concept that a fault zone can focus magmatism. It's certainly been an issue proposed by UNLV, for example. I don't think it's been addressed yet in the program whether elements of that model are tenable or not. So we're trying to evaluate that model just as we're trying to evaluate some of the DOE models in order to basically understand and bring some geologic basis to the probability models.

In terms of what's going to be happening over the next few years ni volcanism, the field volcanism project, which I presented today, is brand-new and has a run time currently now through FY '96. The volcanic systems of the basin range project is either going to be strongly modified or finished off in six months and an additional project started as a result of that.

I think that there's some legitimate questions about where the probability model development fits into that original scheme, for example. That's something we're working on.

Whether we want to make that a task in the volcanic systems in the basin and range and continue that process or whether we want to make it a different project, that's a topic of some ongoing discussion. We just want to minimize the load in terms of the bureaucracy and maximize the amount of time we can spend developing and working on the geologic problems.

MR. HINZE: The testing of the numerical models, the probability models, that's a part of the field studies?

MR. CONNOR: Actually, the probability model development is fitting under the volcanic systems ofc the basin and range project in a general way.

MR. HINZE: That includes, then, the testing aspect?

MR. CONNOR: That's right.

MR. HINZE: At one point here at 1406, there was a plan to do something on the uncertainties in the application of geologic dating for volcanism. Is that out now?

MR. CONNOR: No, that's not out, but it got a slower start than we had hoped primarily because both Brit and I have been doing a lot of reviewing and that sort of thing, a lot of responsive work which takes priority in our organization. So that's got a slower start, but that is definitely part of that work to evaluate the uncertainty in some of the models.

What we have done with the geochronology here is an example of the kind of direction we'd like to take that in with other parameters as well, the uncertainty in the geochronological model and its effect, using one model, on probability of disruption.

MR. HINZE: This is a matter of evaluating the literature and exercising some models?

MR. CONNOR: That's right. That kind of uncertainty testing, as it's envisioned right now, but that task effectively has been pushed back a little bit simply because of a lot of the responsive work we've been doing.

MR. HINZE: We're late, but are there any further questions? That's what we're here for.

MR. POMEROY: I'd like to address a question then to Bill and Linda. Namely, we have heard today basically two sets of work that are being done at the center. Does that constitute the entire volcanological research that's being supported by research at this time?

MR. OTT: It's the entire amount that's actually being supported. There was other work that was planned. I don't know if it appears in 1406.

The next major component was a project which we called modeling of mantle dynamics, which was supposed to be something that tried to couple information on the large structures with more information on eruptive dynamics to gives us a better handle on the performance assessment.

I was going to make an observation to what Chuck just said about progress being delayed a little bit. You see there, to a certain extent, a manifestation, part of the benefit and part of the detriment of having the people at the center doing both the research and the TA work. The research obviously gets funneled right in immediately through their expertise, but it also gets siphoned off in terms of the man hours they can serve on the projects. So sometimes progress is not as rapid as we would like.

I would also like to point out that the active site work that Chuck described is something that we actually didn't ask them to do in the original SOW that was sent down to the center. We were much more focused on basin and range systems, but with a fairly clear objective of what we wanted to achieve.

When the center proposed back to us, they included work on active systems and made a connection to what we wanted to achieve in the project. We responded back that we didn't feel the justification was strong enough and asked for more information. They then came back with that more information, and we met with them and within NMSS and discussed it in detail and then concluded that it was worth going forward with this added component to the program.

So some of the interest that you've shown here and why we're going out after some of them, this is something we ourselves struggled with in beginning the program and finally thought that it was worth sending the center out to do some limited work in this area to see how it would fit in, and I think we're pleased with how it's been evolving.

MR. POMEROY: I want to be sure that is all of the volcanological research that is being done either by the NRC research staff or by the center, does that represent the entire spectrum of volcanologic research within the NRC?

MR. OTT: There is some additional work. There are two aspects. One, Linda was going to try to do some work at Hopkins on a detail agreement which got derailed because of other considerations. We still hope to get some of that work done on single vent systems, and it was a very small piece of the work.

There is a second target of opportunity which has appeared through our involvement with the French in a cooperative agreement where a 20-meter dike has been observed to intrude between two of the reactor zones. As of the last meeting this fall, Linda did some preliminary thermal modeling to try and determine the effect of that intrusion on these adjacent reactor zones, and the consensus of the group was that they would like her to pursue that and do some more complex modeling to try and assess the effects over time of that thermal pulse on transporter migration in that area of the radionuclides from those reactor zones.

So there are some smaller pieces that are actually being done by the staff.

MR. CONNOR: I would just like to reiterate really quickly that we do have several position papers on our use of these modern analogs and particularly with regard to the very focused research questions we were addressing using these modern analogs, and I think that the debate on the subject is really good, but you have to get a handle on what we're doing on these very focussed investigations using the modern analogs, and I hope you get the opportunity to do that by reading some of these position papers as they become available.

MR. HINZE: I would like to follow up on Paul's question. I have a built-in bias here, but I was rather keen to see the draft 1406 there was a proposed study of adequacy of geophysical site characterization techniques for identification os subsurface igneous structure. Has that been eliminated for any particular reason?

MR. CONNOR: Why don't I handle that really quickly. That's actually another part of the fuel volcanism project which I just didn't present today. In fact, we have a program in gear to evaluate some of the geophysical methods that are used specifically at the Yucca Mountain site with regard to volcanism that includes a study of the seismic tomography methods, which is actually being handled with a subcontractor at Arizona State University, and we'll be meeting in March to discuss that and where to go with that evaluation.

We've done some systematic studies at the center on magnetics; for example, how well do aero magnetic and ground magnetic data do in basaltic terrains that recognize our buried subsurface intrusive features and that kind of thing.

Although that didn't get highlighted here, primarily because it's in preliminary stages, that's part of ot it. That's one level that's funded right now as well.

MR. HINZE: I think I'm coming back to where I was before, and that is that we are really very keen to learn what is the totality of the NRC research program in volcanism, and here I'm just learning about something that I had no concept of and that has not come out in the previous discussion.

Obviously, there is a limitation on time. Can you give us some hard copy which presents to us this information? We don't know the status of 1406, and it's very superficial in this discussion.

Bill, is it possible for you to advise on that?

MR. OTT: I think the best thing to do in terms of getting you total information on the two projects is to send you copies of the project plans.

What we've tried to give you today was sort of an update and status on where we are, and for those things which haven't occurred yet, we sort of left them off the plate.

MR. HINZE: There are some things that are happening here in March and so forth.

MR. OTT: Right. The project plan will describe all of the efforts that they planned in each one of the projects, including the GIS project. It would not include other things in 1406, like the modeling or mantle dynamics, which we discussed as projects which would start not this year, but perhaps --

MR. HINZE: Dr. Steindler, I would like to suggest that we formally -- if we have to -- formally ask for that information, and also leave the door open for some discussions, formally or informally, after we've had a chance to review those documents.

MR. STEINDLER: I assume we don't have to formally ask.

MR. OTT: We'll be happy to provide anything we can. We'll get the project plans to you immediately.

MR. POMEROY: Bill, just to clarify that -- I'm not sure that Bill would agree with me, but to clarify, I'd like to know the totality of the program, not just the project plans for these two projects, but things like the Oklo experiment and the other things that you mentioned as well as anything else that exists out there in this area.

MR. OTT: The working arrangements with the CEA in the Oklo project are extremely informal. We presented work to them. The expressed a great deal of interested and offered to provide additional -- it's not funded. We do it as we can. They provided additional samples for us to get additional information.

MR. POMEROY: I know, but I think that's important work.

MR. OTT: We'll give you as much as we can on the description. In terms of the modeling and mantle dynamics, there is probably a very brief description of what we intend for the scope that we can provide, but we have not done detailed project development work on that and probably won't for a few months.

George reminded me of one other component. The grant program slips our minds at times, and we have an educational grant with Johns Hopkins University, which I think ends this year, which is also looking at one aspect of volcanism.

We can provide information on the progress and bring that as well.

MR. HINZE: Was that also true at Florida International University? We see these things, but we don't have a grasp of what's going on. If there would be a sign that we'd been given, we'd feel compelled to have the full information.

MR. OTT: The grants program is supposed to fund projects that aren't directly related to achieving the agency's objectives, i.e., if it's that important, we ought to be funding it directly with project funds. Sometimes, you look at something and you say, "Gee whiz, I'd really like to fund that as a project," and you send it through, and the grants people say, "I'm sorry. If it's that important, you're going to have to fund it with funds. We don't have it." So sometimes the grants slip our minds, also. We have a solicitation, but we don't manage things closely. They are given the money and told to do their thing. They do send reports in to us and report, but we'll get you what information we can on that.

MR. STEINDLER: Let me ask two questions. There are two aspects of all of the research that I gather you folks are doing. One is site characterization evaluation, and the other is input to performance evaluation related to the licensing process. How long do you think it will be before you will have enough information, so you can say yes, we think we know how to evaluate a site characterization document, site qualification document that DOE might get to you?

The second question, obviously, deals with how long is it going to take before you're happy that you can handle a license application? You can use the Pomeroy time scale, 1, 5, 10, or 100 years.

MR. CONNOR: Maybe Keith ought to address that.

MR. McCONNELL: I'll address part of it. We are actually implementing some of the work that Chuck and Brit have been doing in the development of the compliance termination method part of the review plan for igneous activity which is something we didn't mention, but, first, you do a CDS, compliance determination strategy, and then you do a CDM, which is the method, what you will review for. It's basically the details.

We're inputting some of this stuff as we speak into that CDM. In fact, we had hoped to get you that CDM for your review as background to this, but we were unable to do that.

So it's going to occur over a period of years. I think that the research efforts are going to be entered in not at the end of the research project, but continuously over the life of the project, and there will be an end to it, too, I think, and that's perhaps less well-defined, but I think we will require at least from the NMSS perspective an end to the project.

MR. OTT: I'd like to add a little bit to that. That reflects back on some of the work that Brit reported on earlier and some of the discussion we had on the availability of the information in the database.

You've heard that the project is supposed to end in about six months. There may be an indication that we should continue with it longer. Certainly, the initial literature review was put out in a center report and has something like 50 pages of references, which includes citations of every source that we've gone to for data. All that's going to be available. The final report on the project will be available to the public.

The information system that they're using is the arc info database system, and it was developed by the USGS. So all of this stuff is going to be reasonable compatible to systems that are generally available to the public and anyone else in the scientific community.

If we determine that we need to go a little bit farther with the GVIS, we will do so certainly with the concurrence of NMSS, and, certainly, not with the idea that we want to just do database management in the Office of Research for a long time.

I think the observation that Keith made that when we get to a point to put in on this, there may be a need for NMSS to do a minor effort to maintain the database or to add new things as they come up. That's certainly something that disappears probably within the next few years from the research program.

The chart that we originally showed when we discussed the volcanism program with you several years ago showed time frames in which we started the basin and range volcanism because first we thought we needed to do this GIS system or the work to find out what data was available before we went out and tried to fill in the gaps or to find things that we ought to develop ourselves, and then field volcanism is a project to get some data to test some of the models that evolved from this literature search.

The fourth component, the modeling of mantle dynamics was what we conceived of as the integration program that fit all this work together and fit into the IPA program. Obviously, things aren't as discrete as that, and we're already feeding into IPA, but I believe that we see a discrete end. Chuck said that in about two years, he felt he could get enough information on the active systems to do a good job at, say, bounding the types of consequences that we might expect from the small cinder cone eruptions.

I think we've developed a rather finite unbounded program to lead us into the IPA modeling phase where we are able within the five years, I think, to have some kind of integrated approach to assessing the volcanic hazards.

MR. STEINDLER: From that, I can conclude that you believe that you're at least not far out of sync with the current schedule of DOE?

MR. OTT: I don't believe we are. I think we got a la start, but I think we've made a good start.

MR. STEINDLER: Thank you.

MR. HINZE: If there are no more questions or comments, I'd like to on behalf of the committee thank you, Chuck and Brit and Keith and Bill and Linda, for all your excellent input. We appreciate it.

Mr. Steindler?

MR. STEINDLER: Thank you very much.

Contrary to the clock, we're not going to start the next program in five minutes, but we will try to start it in about an hour. So let's break for lunch for an hour.

[Whereupon, at 1:26 p.m., a luncheon recess was taken, to reconvene this same day, Wednesday, February 23, 1994, at 2:26 p.m.]

AFTERNOON SESSION

[2:30 p.m.]

MR. STEINDLER: Let's pick up on the afternoon portion of the first day of the 61st ACNW meeting. Our next topic concerns the process that is to be used by the NRC Staff in the review of topical reports prepared by DOE on specific topics in the High-Level Waste Program.

The lead committee member for this topic, our committee member, is Paul Pomeroy, who may have some few opening comments. But before he starts, I would like to welcome Charlotte Abrams, former member of this group, and we're certainly pleased to have you back.

MS. ABRAMS: Thank you.

MR. STEINDLER: Paul.

MR. POMEROY: I really have no comments, Mr. Chairman, other than to say that there are a few issues that flow from this discussion that I hope we'll have time to at least briefly review, and I'm specifically concerned with how we got to the place we are now in terms of reviewing topical reports on subjects, not only such as erosion, but on seismic hazard, and whether or not they're are possibilities for changing those programs.

I understand you're the sole presenter, Charlotte. If that's correct, I think Keith is here also in case of trouble.

MS. ABRAMS: Actually, let me introduce Joe Holonich, who you all know, and Bill Reamer, who you may not know. Bill was actually the Acting Branch Chief when this was signed out. So we can place all the blame on Bill here.

MR. POMEROY: Very good. Why don't you proceed, Charlotte?

MS. ABRAMS: Okay. If it's all right with you all, I'm just going to sit here and talk from the paper copy. Okay, I'm just going to start with page 2, and actually pages 2, 3, and 4 really just go into some of the history of NRC topical reports and the Topical Report Program. This harkens back to the reactor history.

In the past, topical reports were procedures whereby industrial organizations could submit reports on specific important-to-safety subjects that would be reviewed independently of a construction permit or an operating license. The benefit there was there would be a minimization of time and effort that the applicant and the NRC Staff would spend on subjects related in numerous licensing actions.

The criteria for these reports, and these, again, apply to the Reactor Program, that the report would deal with subjects which can be reviewed independently of any specific license application, and the subjects included design, analytical models or techniques, or performance testing of components or systems, and also that it could be referenced in multiple license application, contains complete and detailed information on the subject presented, and the completion of the topical report would increase efficiency of application review.

Now, on page 5, we go into the focus of high-level waste management topical reports. I'm just going to keep going through these unless somebody stops me.

MR. POMEROY: We will shortly. Believe me.

[Laughter.]

MS. ABRAMS: I'm sure. The high-level waste management topical report focus should be on design, methodologies, tests, techniques, or analytical models under evaluation during the pre-licensing consultation phase, as well as application to a particular technical issue at a specific site.

The reports can consist of a portion of information that's required by the applicant under 10 CFR Part 60

MR. POMEROY: Can we get to that perhaps in a little bit? I understood pretty well what topical reports did in reactor world. I'm not sure that I understand completely how we got to the point of using a topical report, not for issue resolution in this instance, but at least for determining that there were no further questions is the way I believe it's put from the Staff at this point and time.

That's seem to be a resolution of a very specific issue with the one applicant in this particular instance. That seems to me to be almost a fundamental difference than writing a topical report on say the elicitation of expert judgment or something where we're dealing with a methodology rather than an issue, such as erosion or seismic -- perhaps seismic hazard might be a bad example. But if the LONL Report ever got to be a topical report, it could be a topical report apparently under these new regulations or under these ideas.

Is that a correct statement of the Staff's position with regard to topical reports? Or perhaps I could just ask you for a statement of the Staff position with regard to the applicability of topical reports in the high-level waste program. That is, can they be used to essentially reach some sort of agreement with the Staff that the questions have been exhausted at this point and time?

MS. ABRAMS: Well, I think the key words there are "at this point and time." In erosion, for instance, the erosion topical report is addressing a potentially adverse condition. The volcanism one also would. So, essentially what you're seeing is that DOE would be providing information to demonstrate that a potentially adverse condition had been fully investigated and found to not be present at the site.

We caveat everything we say as far as resolution, that it's on the Staff level and that if new information comes to light during the pre-licensing period or during licensing, we would have the option to go back.

One of the things I think that the process serves is it's also a way for -- and I hope that Joe will jump in and correct me if I misspeak here -- I think it's a way to refocus resources even. If things have been -- if the information has been collected to the point that DOE can demonstrate that, then perhaps they need to refocus their program and we need to refocus our review energies.

MR. POMEROY: I think that goal is a highly desirable goal. I guess I'm questioning whether or not topical reports are the vehicle, the appropriate vehicle for doing that, and I guess that I'm also asking the question, were topical reports used to lay to rest certain issues for the time being in other parts of the program, like the Reactor Program? Are there ever instances where issues rather than methodologies or analyses were laid to rest for some time period using the topical report process?

MS. ABRAMS: I am definitely going to defer that one to Joe.

MR. HOLONICH: Thank you, Charlotte. I appreciate that.

Dr. Pomeroy, we tried to model the approach that we would be using topical reports on the High-Level Program very closely to how they were used in the Reactor Program, and in some -- in other areas of the agencies, like the ITFS, the spent cast storage, they use topical reports where they will come in, a vendor will come in and submit a topical report and the NRC Staff will say that design is acceptable to us. Then people who come in and use that licensee's reactor operators can reference that topical report.

To me, that kind of addresses issues to some extent because it deals with design issues and what you're looking at and seismic qualifications or what not. Is there a one-to-one correlation between closing issues in reactors and here? And the answer is no. There is not. My experience in the reactor side of the house was mainly methodologies, codes, critical heat flux correlations, here's the relationship we developed, here's the data that supports it, here's how we statistically characterized it.

We've never had something come in and say we don't think we need to consider thermal hydraulic stability in reactor cores anymore because -- and here's the reason why. We never had topical reports of that nature.

DOE has proposed using topical reports in this way. We looked at them, stepped back, said we think it's capable to use them in this manner. In other words, DOE is going to come in and say we think erosion is absent from the site and here's our basis for that. We would review it and provide comments.

To us, when we say we don't have any more questions, we take that as the definition of issue resolution, meaning that at this point and time with no more questions, we believe the issue is resolved. What we would like to see then is DOE reference that topic when like a progress report so that it's tied back to the site characterization plan and we can keep that higher level 10 CFR Part 60 document complete.

So, there's not a one-to-one tie, but this was one of the areas where DOE proposed they would like to use topicals in a similar way or use topicals, use that approach, and we looked at and we believed it could be done in this program because of the unique nature of the program.

There are -- I would expect DOE to consider using methodologies and describing methodologies in topical reports it wanted to, codes for seismic analysis, description of their performance assessment process. Here's the method we're going to use. Here's the process we're going to follow.

Those are other areas ripe. DOE at this point hasn't chosen that. They just wanted to focus on trying to address some of the site issues. So, that's pretty long winded. I don't know, did I answer your question?

MR. POMEROY: I think you did. Yes. You helped me a lot there, Joe, and I guess that that last concept is especially useful to me, that there are -- they're really are two kinds of things we're dealing with here in some sense.

MR. HOLONICH: Right.

MR. POMEROY: They're both topical reports, but in one case DOE is seeking issue resolution for the -- at this point and time at least, and in the other case they're being used in a more historical sense.

MR. HOLONICH: Yes. Exactly.

MR. POMEROY: Let's put it that way.

MR. HOLONICH: Well, DOE hasn't proposed it yet. But I could see if they wanted to, that option is open to them.

MR. POMEROY: Thank you.

MR. STEINDLER: I'm not too happy with that answer, as a matter of fact. But let me go back a notch. Was the original driving force for even instituting this kind of a scheme in high-level waste in economics?

MR. HOLONICH: When you say economics you mean saving resources, reducing resources?

MR. STEINDLER: I don't know whether you want to call them resources, but however you do it, ultimately everything gets down to economics. Is it an economic issue? Is that what you were trying to do?

MR. HOLONICH: Well, we were trying to look at a mechanism that we could use to review issues and provide feedback to DOE. DOE wanted to use topical reports. We agreed with DOE. We would look at how to use topical reports in the program and outline the paper that we put together.

Is it the economics? I'm not sure economics was the sole driving force in it. I think DOE, they would like to be able to say some issues are resolved at this point and time if they think it's done.

MR. STEINDLER: Don't misunderstand me. I know -- I can imagine at least why DOE's interested. I'm trying to find out why you folks agreed to it. I assumed it started the DOE coming to you saying how about topical reports?

MR. HOLONICH: Right.

MR. STEINDLER: So, you agreed to it in part by economics, but in part to satisfy DOE? Is that what you're --

MR. HOLONICH: To be able to work with DOE, work with the program, yes.

MR. STEINDLER: I want to ask another question. There is continuous reference made in here that once accepted a topical report should be referenced in the license application. What does that mean?

MR. HOLONICH: What that --

MR. STEINDLER: What that means --

MR. HOLONICH: Go ahead. I'm sorry.

MR. STEINDLER: I'm going to give you some options.

MR. HOLONICH: Okay.

MR. STEINDLER: Does that mean it simply is the state-of-the-art up to whenever the date of the topical is and everything after that is fair game for discussion? Does that mean that you've resolved that issue and by reference in the license application you don't need to talk about it again?

What between those two extremes, if those are extremes, would you say the referencing something in the licensing application -- what does that mean?

MR. HOLONICH: Okay. My vision -- I was the one who wrote the plan originally. My vision was based on the baggage I brought from the reactor side of the house. What I saw were things like Westinghouse Electric Corporation would come in and say here is our code for predicting core thermal hydraulics in reactor cores, and we would review and look at the modeling and look at how well we thought it met our regulations and say yes, we think that's an acceptable method to use.

Applicants would then come in and say we've designed our reactor core using the Westinghouse think for code and, therefore, we don't need to go back and have you re-review this again because you've approved it once and here's the topical number with the dash A after it, which indicates NRC acceptance of it.

I had in mind some of my visions in topicals and how DOE could use it would be here's our methodology for predicting seismic loading on surface facility structures. The NRC has reviewed it and approved it. We've applied that today on the design of those structures and we show that we were within the limits and we met Part 60.

MR. STEINDLER: How did you envision the input from sources other than the Staff that are normally allotted to the license application processing scheme, namely intervenors, the public, you know, et cetera?

MR. HOLONICH: Well, we have in the review plan the process laid out as we would do a draft safety evaluation, provide it to DOE, give DOE and all it's program participants, state and local governments, give them about a month to review it, have a meeting with them, a public meeting, to talk about it, give them a month to provide any additional comments, and then issue it.

So, we've built into the process the opportunity for the states, local governments, and any interested member of the public to participate in a meeting to discuss our draft findings before we issued them as final.

MR. STEINDLER: Okay. Let me just make the comment that in the normal process that involves the Atomic Safety and Licensing Board, for example, what you have is not only adversarial procedure and cross examination, et cetera, but you also have a group of independent folks who will look at this license application. You do not by asking. You are both the judge and the jury in this instance, at least as you've described it.

I assume somebody must have -- I'm sure in this wide world -- somebody must have brought that to your attention in some fashion or another and I'm wondering how you plan to resolve that. See if you solicit and you obtain in the course of this discussion commentary but you also dispose of those comments in some fashion or another and then you're the one that makes the decision finally, you've taken that process out of what I would call the unbiased domain of an unfettered licensing board. Hasn't somebody raised that issue?

MS. ABRAMS: It can still be addressed in the licensing hearing. We haven't closed it off from the license.

MR. STEINDLER: But that's exactly the point here. I asked what do you mean by referencing it in the license application? What I thought I heard was you do it the same way the reactor folks do, and that doesn't come up again. Am I wrong? Where have I lost track?

MR. HOLONICH: No. It doesn't come up again unless it's contested in a hearing and then you have to defend it. Several of my licensing experiences in hearings has been Westinghouse topical report such-and-such has not been formally approved and it's used in this application. How can the Staff say that's acceptable for meeting the regulations? And you would have to go in a provide your basis for why it was okay.

So, you know, do we have a licensing process now with Atomic Safety and Licensing Board? We don't have that yet. Counsel, you can correct me. We don't have a hearing. We don't have license yet, an application. But part of the reason we said issue resolution just means no more questions at this time and it doesn't mean the issue is completely closed is so that people could have the opportunity in a licensing hearing to be able to contest and intervene on this subject if they wanted.

MR. STEINDLER: Okay.

MR. HINZE: Joe, I come at this without any experience from reactor side of things. So, I feel I can approach it somewhat unbiasedly, and it seemed to me as I read through this that as we looked at the first of these, focus, the design, the methodology, tests, et cetera,that it was perfectly compatible with the topical report.

When it's applied to a particular technical issue at a specific site I couldn't understand why this was trying to be grouped under a topical report. Was this just to force it into this nice niche that everyone knows about?

I personally felt that this is worthy of a distinction from dealing with technical issues as virtue as contrasted with the design methodologies. That was my view on reading this, that it looked like it was trying to be -- too many things were trying to be forced into one particular name and cover umbrella for it.

MR. HOLONICH: I'm not sure if there's a question there or not, Dr. Hinze.

MR. HINZE: There isn't a question. Let me ask you. Why was it necessary to have both of these items that are on page 5 fit under one heading, under one type of report? Seems to me that there's quite a difference between the application of a particular technical issue at a particular site. There's a difference between that and the general methodology.

MR. HOLONICH: Part of it was being responsive to how DOE wanted to use the topical reports, and they did want to address specific technical issues in the topicals, and so we looked at and we felt like we could accommodate that and that it was reasonable to use topical reports in that way.

Like I said, my experience with reactors we never did that. But DOE was looking to use that, use topical reports that way, and so we looked at it and believed, yes, we can accommodate that.

MR. GARRICK: One appealing aspects of this, at least to me, is that the topical report -- I think you alluded to this -- forces the DOE and the NRC to interact in a more timely fashion than they may otherwise, and I like that. The one thing I would ask from an operational standpoint, however, is have all the lessons learned from the use of this in reactors, and I'm sure they're been many, have they been passed on to DOE, for example, to make the process work as effectively and as smoothly as possible?

Right now one way to pass that on is through the guidelines. So, I'm sure that they reflect what you've learned. But I am also quite sure that in the reactor applications particularly you've learned a great deal about the effectiveness of these and how they should be used and should not be used and something about their scope and what have you, and has anybody analyzed that and put something together for future applicants to use, including DOE?

MR. HOLONICH: The basis for what we have written there -- what we have written here and which outlines some of the uses of the topicals and how we're going to do the review, actually came from NUREG 0380 I believe is the number, which was the NRR Topical Report NUREG, which described the process NRR had worked with and what they finally came to as the most optimal process.

We based it on as much knowledge as we could from NRR and used the NUREG as part of the basis from putting this together. So, I would say yes. We tried to get as much knowledge as we could from the NRR Program.

MR. GARRICK: One other question. Is there any process that encourages topical reports to be developed on issues that are in some sort of order or priority? Or is it strictly up to the applicant to propose the topic?

MS. ABRAMS: No. No. Actually, there is an option in the topical report review plan that -- it's an option given to the NRC Staff that we can recommend ideas for topical reports, too.

MR. POMEROY: I don't know if this is the place to bring it up or not, Charlotte, but I've heard numbers from DOE that indicate they might be thinking of as many 40 topical reports, many of them dealing with issues, not all of them with methodologies or software by far. Do you know anything about contemplated numbers of these and do we have anything like the resources to try to meet that kind of a demand on our resources?

MS. ABRAMS: I can't answer the question about the numbers. I think you'd have to ask DOE. If they , for instance, were going to address every one of the potentially conditions, we would have quite a few, and, in addition, the methodologies. I think we know right now that we can potentially have another one this fiscal year and two next fiscal year for sure. Other than that, I can't tell you.

As far as resources, just based on so far the review of the erosion topical report, I'd say we have used more than we budgeted to use as far as resources.

MR. POMEROY: Right. Thank you. Want to go on?

MS. ABRAMS: Okay. Well, we'll go on to Number 6, page 6. I think we've discussed some of this, that topical reports may be incorporated by reference in the license application if it is accepted by the NRC Staff, and also it's expected that DOE would reference a topical report in their license application annotated outline, which would serve as a basis for -- and it would serve as a basis for preparation of portions of the annotated outline.

Now, as far as bases for the NRC Staff acceptance of a topical report for referencing in the license application the Staff will ultimately determine whether the subject addressed is addressed to the degree that Staff has no questions or disagreements at the time of the review.

Matters presented in the topical report are considered to be resolved at the NRC Staff level unless new information becomes available that could invalidate or call into question conclusions. So, if new information becomes available the Staff really can conduct an additional review at any time and Staff has that option.

Topical reports will not serve as a piecemeal determination that the license application complies with NRC requirements. In other words, DOE still needs to resolve issues in the context of the overall system because the topical reports are geared to resolve issues really pertaining to only a portion of the geologic repository system.

The Staff would need to evaluate the use of the topical report in the license application and evaluate whether or not the resolution remains acceptable in the context of the overall repository system.

MR. POMEROY: So, the argument would be in these terms that because of the interactions of the system this isn't a piecemeal determination?

MS. ABRAMS: That's right.

MR. POMEROY: I think that's a reasonable argument, but one could make the argument, I believe, that this might be a useful way to proceed in some sort of piecemeal fashion in resolving these issues and do a stepwise license review. I'm sure that you and other people considered that at some point. Either of you care to comment on --

MS. ABRAMS: Well, I know in the early stages of consideration of what we were going to do with respect to this, we discussed where does the argument fall apart, and every time we looked at it you could really resolve all the different pieces but you could come up at the end and when you put all the pieces together you might not have an acceptable system. So, that was the basis for putting this clause in there.

I don't know -- does anyone want to add anything?

MR. HOLONICH: I think that's an accurate answer, Charlotte.

MR. POMEROY: Fine. Thank you.

MR. HINZE: I was looking at the document on this it says "and conditions for acceptance." What does that mean? Could you give some examples of that? Under Staff Evaluation, "When a topical report is found acceptable for referencing in the LA the extent of and conditions for acceptance, if any, should be identified." I didn't understand conditions for acceptance.

MS. ABRAMS: I think I'm going to get into that later on in the report -- in my discussion. But if I don't, ask the question again.

Page 8 is just sort of an outline of what I'm going to cover in the rest of my presentation. Purpose of the review is for the NRC Staff to provide guidance to DOF on concerns related to information submitted and what's need to resolve those concerns and to determine if the topical report is acceptable for referencing in the license application, including whether DOE has demonstrated an acceptable method to meet regulatory requirements.

Now, as far as the procedure for submittal -- and I'll just go through the steps briefly here. DOE would submit an annotated outline for the topical report, and the annotated outline essentially is the scope and description of the contents of the report. The NRC reviews that and is supposed to provide comments to DOE within 60 days of receiving that and NRC then would make a determination whether or not the subject qualifies for a topical report.

MR. STEINDLER: What is the basis on which that determination's going to be made?

MS. ABRAMS: That's an interesting question. If it fits the earlier criteria, which in other words as it deals with methodologies, so forth, or it deals with requirements in Part 60. So, the four I gave earlier can be incorporated in a license application.

MR. STEINDLER: Tried to find anything that's excluded. You've discovered the world.

MR. HINZE: I found it rather peculiar to see the report contains complete and detailed information on the subject presented. Complete is a tough word on just an acceptance review. Until you've done a detailed technical review, I don't see how you can make certain that it's complete.

MS. ABRAMS: Okay. Now, this earlier review is just on the annotated outline. It's not the acceptance review of the report, but I can --

MR. HINZE: What did "complete" mean there?

MS. ABRAMS: Well, what we mean -- and I'll get to that -- is it really the data we would need for our review, but I don't believe I answered --

MR. HINZE: No. I don't think review of the technical aspects of it at all.

MS. ABRAMS: We can't make that determination until we get into our technical review. But I don't think I answered the other question.

MR. POMEROY: No.

MS. ABRAMS: And, yes, it is broad. I'll agree. That's all really I can say.

MR. POMEROY: Okay. Go ahead, please.

MS. ABRAMS: So after NRC notifies DOE that the subject does qualify for a topical report, there's no time frame in this step. It's simply up to DOE to provide that report in whatever time they need to provide it. When DOE does submit the report for NRC to evaluate against specific criteria the NRC has 30 days to conduct an acceptance review of the report.

Now, one of the lessons learned in the erosion review was that 30 days sometimes is not enough, specifically if we have to task a center and the center has to task an outside contractor. Thirty days is very difficult to meet. So, we're learning things as we're go along in using this review plan, too.

MR. POMEROY: I guess that was that was the question I was going to ask, and maybe you can approach it as you go through the rest of this, Charlotte. Are we going to talk about how this worked up to the point we're at now with the erosion topical report?

MS. ABRAMS: I think we can and Keith McConnell's here in the audience. So, he can address some of that, too, since his section was the specific lead on the erosion review.

MR. POMEROY: I've heard that name.

MS. ABRAMS: All right. So, if NRC accepts the report for review then we will conduct a technical review, and we have approximately 60 days -- 80 days to conduct that review.

MR. STEINDLER: Is there any reason to believe that that's a reasonable time?

MS. ABRAMS: I think it depends a lot on the topic and the scope of the report itself. So, I think in some cases it's an unreasonable amount of time. In some cases it may be reasonable. Again, I think we run into are we going to have to use outside contractors, consultants? So, there's a lot of factors there and I think we're going to have to look at all of these deadlines.

MR. STEINDLER: Limited experience in looking at data reviews for another agency indicates that if you have any significant quantity of data to evaluate together with concepts the time schedule you have is totally unrealistic. Far too short.

MS. ABRAMS: We're finding that out with respect to the erosion report.

MR. POMEROY: Will there be some changes reflected in this report that reflect your experience with the erosion reports eventually?

MS. ABRAMS: I don't want to speak for management, but I think that whenever we issue a review plan we issue it with the idea that it can always be changed, and we learn lessons as we go along. We, for instance with the SEP, when we reviewed the draft SEP, we did significant revision to that review plan. We revised the study plan review plan twice and we're going to have another revisions real soon.

So, we learn things as we go along and we try to make these better as we go along. So, I would anticipate doing the same thing here.

MR. POMEROY: One of the things that I wanted to ask was in Appendix A you give a total of 40 weeks for the turnaround time between DOE's submittal of the report to you and you're final acceptance or rejection or whatever. That also seems somewhat unrealistic to me. But I wanted to ask, are these binding on you in any way, and in terms of can DOE come back at the end of 41 weeks and say well? Or are these just simply guidelines for the purpose of timing general review process as far as management is concerned?

MS. ABRAMS: Well, these are guidelines that go into our operating plan and when we receive the report this goes into our operating plan and it's closely tracked. We do have some degree of flexibility also if we are -- if we're requesting some data and we haven't received it, then these go on hold. We don't get marked off for that amount of time. But I would not -- DOE does not have the option of saying okay it's -- everything's okay if they don't hear a response from us in that 40 weeks.

MR. POMEROY: Thank you.

MS. ABRAMS: Okay. Just briefly, the contents of the report. The review plan lays out what we would expect as far as the contents, and this is just very brief abstract summarizing the contents and conclusions of the report, an introduction stating the purpose and defining the scope of the report, and that would include things such as results or conclusions and the applicability of the report itself, then the body, which is organized according to the discretion of DOE. We don't prescribe anything there.

As far as the references, DOE will and has committed to furnish all not readily obtainable references to the Staff, and this is laid out in Section 3.4 of the Plan. It's really the same thing that we ask for in the study plan/review plan. They're things that we couldn't go to the library and get, things such as very obscure journals, foreign reports. In preparation or in review references are not acceptable and personal communications are not acceptable.

Then if there are to be long data tabulation, things like that, we would expect to find that in the appendices. Also, diverse or unrelated subjects, the Staff encouraged DOE to put those in separate reports. We wouldn't want to be addressing those in the same report.

MR. STEINDLER: Apparently, you're willing to accept non-peer reviewed material in a topical report in which you're prepared, presumably, to at least in principle say yes, this subject is closable at this point. Does that implay that you're going to evaluate the quality of those data in some fashion independent from what the normal process is?

MS. ABRAMS: I'm going to have Keith add to this if I misspeak here. But in the -- with the erosion topical report we received a peer review report which Staff looked at and also the QA, the technical staff and the QA Staff, and the QA Staff had no problem but I think the technical staff has to look at the data itself.

But I think the bottom line answer I believe is no.

MR. MCCONNELL: That's correct. What we do is evaluate DOE's qualification of existing data and some of the aspects or criteria that are used are have they followed the NUREGS that are in existence on both peer review and the qualification of existing data? Another would be whether there are NRC accepted QA programs in place at the host organizations that are collecting the data?

So, in essence, we're not going to make a judgment on the qualification of data. We're going to let DOE do that and present an argument to us and then we will judge whether they've done that effectively or not.

In the case of erosion, I think we have raised questions of whether they have effectively qualified existing data and we're waiting for, you know, a response on that issue.

MS. ABRAMS: Okay. Before the Staff begins its review, it will determine whether the report satisfies some specific criteria for topical report acceptance. Dr. Hinze, let me know if this answers your question. Criteria are that the report deals with a specific important-to-safety or important-to-waste-isolation subject that requires a safety assessment by the Staff. The subjects, again, would be things like design, methodologies, tests, techniques, or analytical models, as well an application to a particular technical issue at a specific site.

Also, it deals with subject under evaluation during pre-licensing phase and can be referenced in the license application and can be evaluated independent of the license application at this time. Also, that the report contains complete and detailed information on the subject presented and that acceptance will result in an increased efficiency of the Staff's license application review.

Question?

MR. STEINDLER: I didn't understand your second point and I didn't understand it either in the write up. The subject of the report is under evaluation during the pre-licensing phase of the program.

MS. ABRAMS: I think that to me -- and Joe can correct me -- that's kind of a motherhood statement. In other words, all the potentially adverse conditions we would expect to be under evaluation during the pre-licensing situation. But then it could also deal with methodologies which wouldn't necessarily be under evaluation, wouldn't have to be, but they could be things that DOE was considering or want us to rule on.

MR. STEINDLER: I couldn't figure out whether there was any exclusion. I mean what would be excluded from this by this criteria. What subject matter could they possible bring up that's not under evaluation during the pre-licensing phase.

MR. HOLONICH: Charlotte. I think when I wrote it, Dr. Steindler, I was thinking in terms more of DOE may do a number of topical reports on areas not necessarily related to our regulatory program that they might use in other areas on other regulatory requirements or give to different organizations, and I didn't want those topical reports to be submitted to us for review.

Same thought process. Westinghouse would use reports to respond to contracts to utilities that they didn't necessarily submit to us, and that was what I was thinking there. I wanted to make sure anything DOE submitted to us was within the scope of our regulatory job and so that's why I wrote that statement the way I did.

Yes, it covers everything in site characterization and everything in the program, but I wanted to make sure there was not something outside of our area that DOE was using topical reports for that they would be flooding us with these reports that weren't pertinent to what we were doing.

MR. POMEROY: But you would expect that every topical report that you received had a specific bearing on the site, the proposed site?

MR. HOLONICH: Yes.

MR. POMEROY: So, in some sense, these would all be site specific documents in terms of issues.

MR. HOLONICH: Yes.

MR. POMEROY: This guidance, however, I presume is -- and from what I read I know it is I think, but let's just get it on the record that this is generic guidance.

MR. HOLONICH: This is generic guidance in terms of topical reports. The topical reports could be focused on site specific issues.

MR. POMEROY: Right. Thank you.

MS. ABRAMS: Okay. I'll walk through on page 13, the evaluation process. Initially, the Staff would evaluate the topical reports against the criteria and present it on the previous page, and then they would determine if there's need for a technical review and conduct a technical review, which would result in questions or concerns to DOE if necessary.

Then DOE would address those questions or concerns. Actually, there's built into the system opportunity if we had additional questions after DOE addresses questions or concerns, we could actually go back through the loop here again. Also, during the review, the Staff can request additional information that we think is necessary for our review and the DOE would need to respond with that information within 60 days. They actually respond with an amendment to the topical report.

When the Staff finds the topical report acceptable, the Staff would prepare and issue a draft safety evaluation -- and Joe got into some of this a few minutes ago. That draft safety evaluation would include the Staff's evaluation and the basis for the evaluation and our conclusions.

Within four weeks of the issuance of the draft SE, there will be an interaction involving all parties. This interaction was put into the steps to actually provide the state and affected parties as much as anyone else the opportunity to comment. They requested opportunity to comment when we issued an early draft of the topical report review plan and we actually felt like this might be one of the most efficient ways to involve them in the process.

Then the NRC will consider the comments from all the parties and after consideration of all those comments issue a final SE and the time for that is 30 days following the interaction, which again may or may not be reasonable.

MR. STEINDLER: In the document itself, you indicate that the focus of the review is to be on design, methodologies, tests, techniques, or analytical models, and notoriously missing from this list is data. Why?

MS. ABRAMS: I would assume that we're considering the data would be submitted as part of the information to address a particular technical concern. But I'm trying to think of an instance where we could just be looking at data?

MR. STEINDLER: Well, it doesn't have to be just looking at data. But you know you provided a litany of things that could be under evaluation?

MS. ABRAMS: I guess we felt like we would be evaluating the data --

MR. STEINDLER: Well, let me give you a for instance. We just heard from the volcanism folks about the generation of a very large database. Some place along the line if they're going to use this database to draw some conclusions pertinent to either a model or some kind of licensing related, Part 60 related determination, surely somebody's going to go back and say let's have a look at those data to see whether or not (1) they're any good, and (2) whether you've done it right, you're using them in the right way.

Don't you have the same problem here? No?

MS. ABRAMS: I think we're doing that as part of the erosion review. We are looking at erosion data there. And we would do that as part of the volcanism review. We got a status -- a topical report on volcanism. So, we would do it in the context of our technical reviews of specific topics.

I see what you're getting to. I'm just trying to think of an instance where we would ever do it without doing it as support for a technical position.

MR. STEINDLER: Again, the department head in the processing of qualifying in this case engineering related data on wastefulness had a very careful distinction between the procedures that were involved in getting them and the Board, our board, to review this thing and the data packages that finally described the performance of a particular glass or waste formed under specific conditions, and that was a data process review. Once that was done, that was nominally accepted as acceptable data.

MS. ABRAMS: We can certainly add that in revision.

MR. STEINDLER: If it never comes up, then it's an academic point.

MR. POMEROY: Charlotte, before we leave that, just going back to one statement you made with regard to DOE addresses the questions that the Staff has after the initial review process, and you said I think that DOE has then 60 days to respond.

MS. ABRAMS: That's correct.

MR. POMEROY: Again, is that a guidance to DOE or is that a requirement to DOE?

MS. ABRAMS: Yes, I think in any case there would have to be consideration of extenuating circumstances.

MR. POMEROY: Right.

MR. HOLONICH: It's just guidance, Dr. Pomeroy. I mean we would like to get it in 60 days to keep the review rolling. If it takes 90 days, then obviously --

MR. POMEROY: It just takes four weeks longer.

MR. HOLONICH: Right.

MR. POMEROY: To get the whole process done. Thank you.

MS. ABRAMS: Okay. Page 14 is really pretty much a reiteration of things I've already said, that if a topical report is found to be acceptable for referencing in the license application, the Staff in their transmittal letter will notify DOE of the extent of and conditions for acceptance in its SE, and the issuance of SE does not constitute any commitment to issue any authorization or license. It just constitutes Staff acceptance and doesn't affect the authority of the Commission, the licensing board, or anyone like that.

MR. POMEROY: Okay. Are there questions from the --

MR. STEINDLER: Yes, I've got one. Supposing tomorrow morning for some reason or another this whole process disappeared and the topical report scheme that you've just outlined is no longer available. What's the impact on either the Staff or the Commission or the licensing process? But don't answer for the DOE.

MS. ABRAMS: I think that then it makes it a little more difficult for the Staff to be able to review that license application in the three year time period that we are allowed. In other words, we're hoping that this will help us expedite that three year review.

MR. HOLONICH: I think, Charlotte, one of the other things, Dr. Steindler, is we would like to have to look for other mechanism that DOE has that we might be able to use to get them to focus and address issues like semiannual progress reports. We might look form more in them to address erosion and the absence of extreme erosion from the site if they don't do a topical. So we would be looking to other mechanisms, too, to help us get the information need in a timely manner.

MR. STEINDLER: I think the difference between what you said and what Charlotte said is a shift in time more than anything else.

MR. HOLONICH: Yes.

MR. STEINDLER: Yes. Okay.

MR. HINZE: A couple of things, Charlotte, is this a pass/fail situation in terms of the evaluation, either you accept it or you don't accept it? The reason I ask that is I'm going back to my conditions for acceptance. Could you give me some examples of how you would caveat an acceptance?

MR. HOLONICH: Charlotte, can I --

MS. ABRAMS: Yes, go ahead.

MR. HOLONICH: Once again, Dr. Hinze, I bring my reactor experience with me and what we did in reactors, and one of the things that happened was, for instance, Westinghouse had submitted what was called an improved thermal design procedure which shaved a lot of margin off of things and sharpened the pencils real tight, and we said, okay, you can use that methodology. It's acceptable to use to design reactor cores. But you have to provide us all the uncertainties associated with all the instrumentation that measures the variables because you've sharpened so much we want to make sure you've accurately account for instrument uncertainties.

Under the old method, which is deterministic, where you set everything at its worst limit, we think you probably don't have to worry about those uncertainties because there's enough conservatism build in it. But when you sharpen your pencil and use it to a greater level of detail we need more justification and more information.

So one of the conditions on using this methodology is you have to provide us with all the uncertainties associated with the instruments that measure the parameters that serve as input to this model.

Another example was that Westinghouse had submitted a code that it said could be used for transient and steady state analysis. The Staff looked at it and said we don't think you've accurately modeled transient conditions and so we find the code acceptable for steady state conditions but it cannot be applied to transient conditions. That's kind of what I envisioned when I talk about the conditions and the limitation on the use of the reports.

MR. HINZE: I have a hard time translating that into technical issues, though, at a specific site.

MR. HOLONICH: Once again, my focus was designs, methodologies --

MR. HINZE: I think that's much easier to deal with than this technical issues, such as erosion, and it bothers me that there is this option for conditions of acceptance without any constraints on that.

MR. HOLONICH: I'm not sure that would apply to something like erosion. To be honest with you, I've got to write it to apply across the board. But it's to be implemented as needed on specific areas and on specific topical reports.

MR. HINZE: They're going to -- there a lot of people reading this document and they're going to be looking for ways in which to criticize this document and the conditions for acceptance. Is that a way to slip out of the situation, the caveat? And that perhaps might be misunderstood.

I guess going back to your reactor experience and this also explains and for proprietary reports.

MR. HOLONICH: Right.

MR. HINZE: I assume that you have some codes that are proprietary and so you give some kind of an overall statement regarding them. But, again, I don't think that pertains to the technical issues at specific sites.

MR. HOLONICH: It probably does not and that's part of what goes in to determining something's proprietary is the applicant has to make the case and we agree with him before we cede it.

MR. HINZE: I guess it goes back to my original statement, which was not a question, that you're trying to cover too much with this document.

MR. HOLONICH: Oh, I see.

MR. POMEROY: Charlotte, can I ask you a couple pages, 9 and 10, of the document itself relate to a statement of IQA responsibilities basically. Is this the only place that such an IQA responsibility is written down or is the only place for topical reports?

MS. ABRAMS: Only place for topical reports. Actually, there is verbiage similar to this in the state plan review plan and in the SPE review plan, and really it's to let people know as far as bookkeeping what we would retain. It's to let the project manager know what the responsibilities are, and believe me when I tell you that we get audited by our QA Staff on these because I have been audited on a number of occasions with respect to reviews.

MR. POMEROY: There's one other question I wanted to just clarify a little bit. I think I understand the process. But when a topical report, such as erosion, comes into our system after some agreement about the annotated outline, and perhaps I'm asking really about the annotated outline, how does the process work, if you can do that quickly, in getting to the appropriate section leader? I guess Keith in the case of erosion for example.

How is the lead reviewer selected? Is he selected by the section chief or the branch chief or some combination of those? How does that process work?

MS. ABRAMS: It generally comes addressed to the Director or the Project Directorate, Joe, and, of course, he passes it on to me or the appropriate project manager and essentially I let him know -- you can tell pretty much what discipline would take care of it.

But I send it out to the appropriate discipline by note, providing timeliness, deadlines, and saying it's been presented for review, and also asking that lead section to provide me with information on whether they're going to need assistance from the Center or whomever and any problems they would have with the deadlines that I give in the note.

Now, it's up to that section to task the Center. I don't do that. But I do like to be kept in the loop.

MR. POMEROY: Would that apply -- I can see a topical report coming in that might encompass geology and hydrology for example. Where would the selection take place of who the lead section or how the lead reviewer was selected, basically?

MS. ABRAMS: Well, it's really the group that it's predominantly -- the report's predominantly in their area. With respect to the erosion report, even though the geology section has to lead, they're is actually some input from the geochemistry section. So, one section is tasked with the lead and then they are supposed to let me know through their section leader that they need help from another section.

That is done on a section to section basis.

MR. POMEROY: But you would then facilitate that arrangement, shall we say?

MS. ABRAMS: Generally, the lead section facilitates that. If they need some assistance, then I can provide it and actually we can get the branch chiefs involved if we need to.

MR. POMEROY: Keith?

MR. MCCONNELL: Yes. I would expand on that a little bit in that in our license application review plan, which is guidance to the Staff, we have to this point identified both the section lead and any support from other sections for each regulatory requirement topic, erosion being one, and that is documented in what you will see as LARP Zero, those assignments. So we would go to that, too, to make assignments to a particular section or a particular branch in that case.

Then within the sections themselves the Staff is assigned areas of responsibility, again, based on these regulatory requirement topics. So, that particular Staff member, whomever has been assigned that responsibility, would be the lead technical person.

MR. POMEROY: Thank you.

MR. STEINDLER: Couple of comments. First off, is there anything specific that's required from the Committee as far as you know?

MS. ABRAMS: Not to my knowledge.

MR. STEINDLER: Okay.

MS. ABRAMS: I think if you have specific comments --

MR. STEINDLER: You probably heard it.

MS. ABRAMS: We would definitely take them under consideration when we revise it.

MR. STEINDLER: Let me ask a specific question. Are there any commitments that are implicit in any of the things that either the Staff or essentially the Commission is doing by accepting and in a sense approving the topical report and its contents?

MS. ABRAMS: I'm going to let Bill follow up on what I say, but I think that in Part 60 there are words that say the results of our reviews do not commit the Commission or the licensing board when it comes time --

MR. STEINDLER: That's what it says in here. You know I mean there's a legal statement which I can find someplace in here that in effect it isn't binding on the Atomic Safety and Licensing Board and the Commission and so forth and so on and the Atomic Energy Act as amended. But I'm trying to brush through all that nonsense and see whether or not buried in here there are any commitments.

MS. ABRAMS: I don't think there is when you get to that point.

MR. REAMER: That's right. No binding legal terms.

MR. STEINDLER: Nothing buried in here. Okay. Well, it strikes me that considering the amount of flack that you're likely to get from various folks about this process in general you might want to make that so explicit that there is no question left in the mind of the reader, you know if you're ever going to do this, revise this thing, that might be one thing to do.

MR. HOLONICH: Dr. Steindler, if I could just add, we have sent this out and we had a meeting back in May with the state and DOE and other interested members of the program and the language you see in there the state of Nevada advocated that we include that kind of language. So, I think we've been through a rigorous review but just to give you that background.

MR. STEINDLER: I was aware of that. The argument that you made by the way that the primary utility, frankly, that I saw and out of the comments that I've heard so far, is if we don't have a process like this it looks to -- it seems to me that what you said is it looks to you folks that processing a license application in three years won't be possible unless you got somewhat of a head start on this and begin at least a technical review and this is a mechanism of doing that. I think that's not an unreasonable approach. But that, frankly, may turn out to be the only sensible justification for this exercise that you've just gone through.

I'm not particularly clear on what you folks mean by referencing something in referencing a topical report in a license application and what that implies. You've used that term several times in here. The implications of that for the entire process is not very clear. Maybe I've just not found it and it's clear someplace and it's clear to you folks, but again, to avoid any great misunderstanding it seems to me that the meaning of that action, the implications of that action, might be spelled out someplace to, again, remove any doubt.

I think that's basically all that I have.

MR. POMEROY: Bill? John?

[No audible response.]

MR. POMEROY: If there are no other questions, then thank you very much, Charlotte. Before we let you go, I'd like to say that we understand that you're moving from one position to another. If that all happens -- and Joe is also I believe -- I don't know about you, Bill -- I just hope that we have the opportunity to interact with you in your new roles in the future, and thank you very much for coming.

MS. ABRAMS: Thank you.

MR. STEINDLER: It turns out unbeknownst to some of us, somebody built a 45-minute break into the schedule and we're way ahead of schedule. Everybody here. Fifteen minutes? All right. So, let's take a 15-minute break and then we can turn to the next and last topic of the day.

[Recess.]

MR. STEINDLER: All right. Our next and last formal topic for today's part of the meeting, we're going to hear from representatives of the Office of State Programs about what actually turns out to be a fairly complex and very important subject, namely compatibility of agreement states, state programs.

And I assume we will touch on the associated issues of adequacy of programs, common and noncommon performance indicators, operational and programmatic elements of the performance indicators, all those related presumably to the protection of the public health and safety.

These activities are carried out by the states under the provisions of Section 274 of the Atomic Energy Act.

Paul Pomeroy has joined me on being the lead for this committee and he has said that since he's already done his work for today, I am supposed to handle this. But I have it fairly easy, actually, because I'm going to turn the floor over to Dick Bangart and let him introduce Shelly and whoever and make some opening comments, perhaps.

Excuse me, Dick. Is there a green button on that?

MR. BANGART: Now, should I go over that one more time? I'm sorry.

We do have the briefing this afternoon focused specifically on the new compatibility policy. And we don't have a formal presentation prepared that will address common performance indicators and how we see those being used in agreement state re-use. We will be glad to address questions, if you have them.

In my introductory remarks, you will see that I think it's important that the committee keep in mind other developments that are going on in parallel with the development of the new compatibility policy. So perhaps that's an opportunity for us to come in the future and brief you on this additional major element of the program.

We are pleased to have the opportunity to brief, discuss, and receive comments from the committee on the draft agreement state program compatibility policy. We do plan to move forward during this year to incorporate your comments, incorporate comments from the agreement states, and incorporate comments from other interested parties and implement what will become the new compatibility policy.

The committee may want, as I said, to receive additional briefings as we finalize and implement the policy, especially as that policy relates to agreement state low-level waste disposal regulatory programs.

As I indicated, I encourage you to, however, not review the draft compatibility policy in isolation from other initiatives that are under way within the agreement state program. A number of those other agreement state program modifications are being evaluated at the same time as the draft compatibility policy is being developed. Some of these program -- these other program modifications are closely linked to the compatibility policy itself.

For example, the most advanced of the related program modifications is indeed the development of common performance indicators to assess the adequacy of materials programs as they are carried out both within NRC regional offices and in the agreement states. The review team that would assess agreement state program adequacy using the common performance indicators would also review the compatibility of an agreement state program using the new compatibility policy when it is approved and final.

Some of the other initiatives that we are working on that might be of interest and that relate or may relate to the compatibility policy include the development of additional agreement state program Commission policy statements, procedures for the suspension or revocation of a state agreement because of inadequate or incompatible programs in a state, and establishing criteria or thresholds for Commission involvement in agreement state program issues or agreement state program review findings.

So, again, as you review the development of the new compatibility policy as it relates to agreement state regulation of low-level waste disposal, I encourage you to maintain an awareness of other agreement state program modifications that relate to the compatibility policy so you can put that policy in some broader perspective.

The briefing that we've planned this afternoon will be conducted by Shelly Schwartz, the Deputy Director of the Office of State Programs. He has been the leader of a special working group that has been tasked with the assignment of developing the new compatibility policy. I don't think there is anybody in NRC that has a broader perspective and a greater historical insight on compatibility than Shelly does.

So if there are no questions, we will begin the formal part of the briefing.

MR. SCHWARTZ: Dick, thank you very much.

Mr. Chairman, if I may, I'd like to do the briefing from here. That way we can have a dialogue --

MR. STEINDLER: Is that microphone on?

MR. SCHWARTZ: Thank you.

I would also like to introduce Ms. Cardelia Maupin. Cardelia has been responsible for taking the lead in the office for most of the work she's done in the investigation. And you'll see her name prominently on all the papers on compatibility.

I add my good afternoon to Mr. Chairman and members of the advisory committee and staff. We're here to discuss with you the staff proposal for the new adequacy and compatibility policy statement for agreement states. I think you all have copies of the viewgraphs. Graph 2. This is the background and outline of what I've prepared to discuss with you today. And I will be providing you this information.

And it tracks pretty much with two Commission papers, one SECY 93-349 and the next Commission paper that followed that, SECY 94-024 -- 025. These papers provided the Commission with the details and additional information on the new proposed policy and recommends that the Commission publish it in the Federal Register for a 90-day comment period and conduct a workshop.

On the next viewgraph, past agreement state compatibility concerns were discussed and probably expressed most succinctly in a March '91 letter from the Organization of Agreement States. The task force report from the

Organization of Agreement states on compatibility.

What was said in that task force report can best be summarized by five points and five questions that were made in a January 24, '91 letter from Tom Hill from the State of Georgia, who at that time was chairman of the Organization of Agreement States, then Commissioner Ken Carr. And for the record, I would just like to state what their concerns are.

Based on preliminary discussions among the agreement states, we have broken the subject of compatibility into the following specific issues:

One, what is the meaning of compatibility?

Two, to what does compatibility apply, regulation provisions, totality of all radiation program elements, administration of the programs, et cetera?

Three, how is it implemented? At NRC's discretion, as a joint effort, or is there yet some other approach which has not yet been determined?

Four, what is the legislative and historical background of the issue and has that frame of reference been used in carrying out the NRC AEC agreement states program since 1962?

And, finally, and he underlines, most importantly, how does the implementation of compatibility relate to the protection of public health and safety?

Following receipt of that letter, these and other issues with respect to the subject of compatibility agreement states were addressed in SECY 91-039 in February of 1991 and in SECY 92-243 in July of 1992.

In January of '92 -- January 22, 1993, the Commission directed the staff to develop a policy, a new policy on compatibility. As Dick mentioned, we established a working group and I had the pleasure of chairing that working group, and we had members of the Offices of Nuclear General Safety and Safeguards, Research, Office of General Counsel, and also the Office of State Programs. And we also had the benefit of some information from some of the agreement states. And at that time, we had the sitting officers of the Organization of Agreement States, Wayne Kerr of the State of Illinois, Bob Kulkowsky, City of New York, and Tom Hill, the State of Georgia. And also had Terry Frizee from the State of Washington, who helped develop an issue paper, along with some expert advice from a consultant by the name of Jerry Parker. And Jerry is retired and he is retired as Assistant Commissioner for Health in the State of Massachusetts.

The task that we took on ourselves was first to develop an issues paper that we could then say, here are the issues associated with compatibility. And once we can get some agreement as the scope of the issues, understanding those issues, then maybe we could start and sit down and develop a coherent policy on compatibility.

We had a draft issues paper that we discussed at a meeting of the states, a public meeting of the states, on May 20, '93, which was coincident with the annual meeting of the Conference of Radiation Control Program Directors. Based on the information we received there, we finalized that issues paper and it was published in June, on June 29, 1993. And if you don't have a copy of that I'll provide it for the record.

And then, based on the workshop that was conducted, for the public workshop in July here in Rockville, with agreement states, non-agreement states, members of the public, the regulating community, and public interest groups, we gathered our first fledgling attempt at trying to craft a new policy on agreement state compatibility.

That was presented to the Commission in October. First, we briefed the Commission in August on what we heard from the states, and then in October we put this draft paper out and briefed the agreement states in October of this past year.

On January 24, 1994, we briefed the Commission and what I'll be briefing you today on essentially tracks what we briefed the Commission, and that refers back again to a

SECY 93-349.

The next viewgraph. In order to understand compatibility, we reviewed -- the group reviewed Section 274, the history of how the agreement states program has matured over the years, and what its relationship with the Atomic Energy Commission and now the Nuclear Regulatory Commission. And in reviewing these and the agreements, the following principles seemed evident to us.

That the agreement state program recognizes the interests of the states to regulate these kinds of materials, the Atomic Energy Act materials. It recognizes the need for cooperation between the Commission and the states as co-regulators, promote an orderly regulatory pattern between the Commission and the states.

And Dick and I have been trying to use the words "a coherent and comprehensive, cohesive national regulatory program." And I think that's what we're about, to try and put a program together with equal protection.

Provide coordination and development of radiation standards and other policies. And that there are two separate requirements: adequacy and compatibility. And, further, that the NRC must review periodically the adequacy and compatibility of the states in carrying out their responsibilities under Section 274.

Next viewgraph.

What did we hear during the rather extrapolated process of talking to the states and talking to the regulated community and others? The states -- and again, when I say "the states," there's always -- I can't generalize because if I characterize the states as saying one thing, there'll be three or four states that will say, no, that's not what I believe. But this generally characterizes what we heard at the workshop.

And that is that the states generally would like a minimum number of requirements for compatibility, which is maximum flexibility in carrying out their programs. They agree on uniformity for interstate commerce, uniformity of radiation standards, and that there be early and substantive involvement of the agreement states with NRC in development of new regulations, policies, and programs.

The regulated community, I think the message was pretty clear, that they are interested in strict adherence to uniform national radiation standards. The environmental community agreed that federal, states -- and I think they generally agreed to this, that federal and state requirements are minimum requirements. And that local flexibility to adopt more stringent requirements should be allowed.

Next viewgraph.

MR. STEINDLER: Who is the environmental

community?

MR. SCHWARTZ: We had a number of individuals, in particular Judith Johnsroot -- I can't remember the name of the organization that she represented. We had representatives of ERS, a representative of OKER, and one or two others; I can't remember. But they stood up and made these on-the record statements.

MR. STEINDLER: Were they national organizations for the most part, or were they local?

MR. SCHWARTZ: Some national, some local. Most of them had the national imprimatur. And they had -- they are, I think, well known to others in providing comments in other regulatory arenas and making themselves known.

MR. POMEROY: Would one of them have been the National Resources Defense Council?

MR. SCHWARTZ: We did not have anybody from NRDC.

MR. POMEROY: Would one of them have been Greenpeace?

MR. SCHWARTZ: I'm sorry. Cardelia is trying to help.

Judith Johnsroot was a representative of the Sierra Club and other organizations.

Thank you, Cardelia.

Since we believed -- this is again the group believed that for clarity it was necessary, as best we could, and I'm on viewgraph six, as best we could to differentiate between adequacy and compatibility, and that is to find what's necessary beyond protection of the public health and safety, what is the compatibility component.

We felt there was a need to provide predictability, to provide a coherent distinction that would eliminate what the states think is perceived arbitrariness of current compatibility determinations. So that we try to define the relationship between adequacy and compatibility as adequacy being the component that provides for an acceptable level for protection of the public health and safety in an agreement state and the compatibility component would provide for the overall national interest in radiation protection.

Slide seven.

Therefore, we proposed to the Commission that the adequacy component requires that the level of protection of public health and safety be equivalent to or greater than that provided by the Nuclear Regulatory Commission through our programs. It would not require that NRC requirements be implemented essentially verbatim or through a particular mechanism as a regulation -- such as a regulation, unless one of the compatibility criteria for identical adoption needed to be met. And I'll get into that a little later.

And further that the criteria for flexibility would be that more stringent requirements, including dose limits and effluent releases, do not preclude or effectively preclude a practice, nor more stringent dose limits are only applicable to one class of licensee or all licensees in a particular geographical area. Those are the flexibility criteria that the staff is proposing.

MR. HINZE: Shelly, if I can interrupt, what was the reason for this being limited to only one class of license within a state?

MR. SCHWARTZ: It gets to the point of who sets radiation protection standards. It is the Commission's view and our view that when the NRC establishes radiation protection standards, it should apply to all licensees and that if the states could make a case because of local needs, local conditions, that they could have a limited flexibility to put different requirements for a single class of licensee where the rest of the radiation protection standards across the board would still not be touched.

MR. HINZE: On page 7 of 349, it states, "However an agreement state shall not adopt more stringent regulations which will bar or preclude a practice without" -- and I emphasize without -- "an adequate safety or environmental basis."

Political considerations aside, then.

MR. SCHWARTZ: Political considerations aside.

MR. HINZE: Right. Political considerations would not be included in the environmental basis?

MR. SCHWARTZ: That's what the staff is proposing.

MR. HINZE: How is it going to be determined that there -- that this is not really a political consideration but an environmental. Because if my reading on the following page was that more stringent requirements will be reviewed by NRC, and then it just kind of falls dead. It doesn't say very much beyond that.

Can you expand on how you see that action going?

MR. SCHWARTZ: I will attempt, because we are laying out a proposal and a concept without a lot of underpinning on the details of what that adequate showing would have to be. That the state would have to make a showing that it's not banning a practice arbitrarily. It's not precluding a practice arbitrarily.

But there is a -- and one example that we gave in the paper is an example, the one about the sewer, the Florida one, because of the high water table, or the example in Tennessee where they're concerned about effluent concentration in the sewer, so they put requirements on the effluents coming out of the facilities in that area so they wouldn't have a problem with reconcentration.

Those are the kinds of things, examples that we use, that characterize and bound what I would say the staff would have to provide the commission, is the bounds of how far a state could go without going over the line and being arbitrary.

I'm not sure I helped.

MR. STEINDLER: In the course of your discussion with the commissioners, you got into a discussion concerning the role of ALARA, the invocation of ALARA as a justification for shifting not a standard but a regulation. And I certainly understand -- at least I think I understand the distinction between the requirement for a standard being uniform across the country, whereas the actual regulation may be different.

But it struck me as I was reviewing that that ALARA is being used in a kind of a strange way, and the distinction between ALARA as a technical issue and ALARA as a surrogate for a political issue disappears. In fact, it allows, I think, and judging by the test that I sense that was being -- that you were being subjected to during that hearing or that briefing, it struck me that the ALARA then can be used as an accordion to set any kind of regulation, regulatory limit you want, recognizing that if, for example, the current Part 20 is 100 millirem and Illinois wants one, that's okay. If they got down to .001, then somebody might arbitrarily say that's really pretty unreasonable.

But that allows you, perhaps, six orders of magnitude under the umbrella of a nominal health and safety issue. Which really probably isn't a health and safety issue in any demonstrable sort of way.

The concern I had was the same one that this committee perhaps 15 years ago encountered when it was asked to comment on the participation -- in those days at least -- the participation of localities in setting the requirement for participation in emergency drills for reactors. The groundrules are, and were then under discussion as to whether or not a locality, for example a set of trustees of a county, were to be required by some requirement to participate in an emergency evacuation drill for reactors. The absence of their participation therefore voiding the possibility of running that exercise, and that in turn impinged drastically on the ability of that reactor to get a license.

The state has the same power by the use of ALARA. How are you going to avoid that?

MR. SCHWARTZ: I'm not sure I have an adequate answer for that. It is an issue that --

MR. STEINDLER: Did I misinterpret what I thought I heard?

MR. SCHWARTZ: No, I think you said it correct.

MR. STEINDLER: Oh, okay.

MR. SCHWARTZ: Because you could use ALARA -- you know, we are making a statement that the state has flexibility to run an adequate program, and that after the Commission decides that maybe this is the right concept, the right framework, the staff is going to have to sit down and really flush out what are the details of an adequate program.

Within that concept could be the ALARA concept and then the staff and the Commission would be faced with saying when is ALARA being used to frustrate a particular process or procedure? I understand the point. I am not sure how I can address it any better.

MR. STEINDLER: Okay. Let me just make one comment. If at the same time you are putting your policy together, you point out that things like ALARA are not goals, they are not numeric, they are a process. Then you can avoid that trap that I thought you were being led into. There is ample precedent for the general notion that ALARA is not a target. It is a process.

MR. SCHWARTZ: I am aware of the Emergency Planning Preparedness business and how we went through that regulatory scheme.

MR. STEINDLER: Okay.

MR. SCHWARTZ: Thank you for the comment.

MR. HINZE: If I can, let me go back to my question about this going to the NRC for review. Do I understand correctly that the plans are that if this is acceptable in principle to the Commissioners, that then you will flesh out how the NRC will review this and what are the criterion and all that sort of thing?

MR. SCHWARTZ: Yes, there is a lot more on both adequacy and on the compatibility.

MR. HINZE: Okay. That answers a lot of the questions that I have.

MR. SCHWARTZ: Okay. Oh, yes. There is a lot more both in the adequacy and the compatibility framework that needs a lot of fleshing out among the staff and also in working with the Agreement States so that they fully understand because they are stakeholders in it as well.

MR. HINZE: There was one other question that related to this one class of license and that was the word "local" in the SECY. Does local mean state, or does local mean what local means to me, that it may be a county, it be a -- how far down are you going to break this?

MR. SCHWARTZ: In our concept, for Agreement States, it is state because the --

MR. HINZE: The word "local" is used. Is that meant -- is that just one way of saying --

MR. SCHWARTZ: There is one condition and that is one example. If you want to say that New York City is local because that is the only "local" Agreement State Program that we have because in the State of New York there are really four programs -- environment, health, labor, and also the City of New York.

So in that context, but we are not saying "change local programs." But for local needs and conditions -- again getting back to the sewer reconcentration, as for that local geographical area, the state could change the requirements because -- not standards, the requirements -- because they had a concern.

MR. HINZE: But you are doing that on a state-wide basis?

MR. SCHWARTZ: That's correct.

MR. HINZE: Okay. That wasn't clear to me as I read the document.

MR. BANGART: I just had a couple of comments. One, the more stringent dose limit really is there for one additional main reason and that is to accommodate the existing situation as it relates to agreement state regulation on waste disposal. Whether you call their more stringent requirements as standard or radiation protection standard or dose limit, it does allow that to give the state that flexibility to be what is "local" or state environment as far as the population.

I would agree that whether or not a driving force is a political consideration or an environmental consideration may be difficult to determine in a situation.

But one of the other actions that were tasked with But one of the other actions that we tasked with addressing is to establish criteria for when we in the Office of State Program and the staff have issues on our plight that deserve Commission consideration. This is a review and a decision. This is a premiere example of the kind of issue that I hope will capture by that criteria that will establish as to when an issue should be brought to the attention of the Commission for consideration.

MR. STEINDLER: Okay. You are not off the hook on page yet.

MR. SCHWARTZ: You saw me turn already.

[Laughter.]

MR. STEINDLER: I just thought I would warn you in advance.

A considerable amount of discussion was had as to what you mean by "practice." Let me just focus fairly quickly in on the low level waste aspect. State "A" says to the world at large, "I will not allow you to do shallow land burial." And for whatever rationale is used, does that not constitute a prohibition of a practice? I know you got into a five-ring circus with trying to figure out what it is that a practice was, but a four-ring circus. You're right, a four ring circus.

MR. SCHWARTZ: I stand corrected.

[Laughter.]

MR. STEINDLER: But I was wondering whether, you know, a month having past, you could clarify for me whether you have come to any conclusions.

MR. SCHWARTZ: Let me deal with it first and then I would like Ms. Maupin to because she did a lot of research on the response.

By practice we were not implying the shallow land burial was a practice in the context. We would say low-level waste was the practice, the disposal of low-level waste was the practice. Maybe there are other ways to say it.

But our intent was to say, "Shallow land burial is not a practice." Disposal of low level waste was the practice we are concerned about and therefore, just banning -- I won't say "just" -- banning low-level -- shallow land burial is not banning a practice.

Do you want expand at all on the practice?

MR. STEINDLER: Let me just jump in before you get a chance.

MR. SCHWARTZ: Yes.

MR. STEINDLER: I'm sensitive to the Commissioner's comment at that point in time when she expressed concern that you are shifting from a health and safety issue to potentially an economic issue. Her concern -- and I am trying to pursue that a little further so I understand where you finally ended up, was that she certainly didn't want to see health and safety regulations turned into an economic battleground.

Well, that is not what she said, but that is ultimately what she meant.

MR. STEINDLER: I understand. Well, it is not our intent to put it on an economic plane. The states have the responsibility on the Low-Level Policy Act Amendments to take care of the low-level waste. We didn't want to allow them to shift the burden to someone else.

MR. STEINDLER: That, I think, is the rationale. Absolutely, I think that is exactly right. The difficulty I am having is that I can move from shallow land to burial which is where we are supposed to be to incineration, for example, where we are not supposed to be.

If you don't like incineration, then the issue is are you barring volume reduction by barring incineration? Does that constitute the demise of a practice?

I realize that is a slippery slope, but I had a difficult time trying to unravel it. I would be happy to hear what you finally came up with.

MS. MAUPIN: Okay. In SECY 94-025, dated February 4th of this year, we tried to come to grips with the definition of the term "practice." Basically what we decided upon is that basically the practice applies to very general activities involving the use of radioactive materials such as industrial radiography, low-level waste disposal.

And it could also include those specific activities conducted within those very broad activities concerning the use of radioactive materials.

I would like to say that on the issue of shallow-land burial, if I might, that originally when we looked at the issue of banning shallow-land burial, which came up with the review of the proposal from the State of Pennsylvania, we were directed by our legal counsel that we did have to have Commission input on whether or not that was compatible with NRC's regulatory program.

The Commission decided at that time, after review of that, that banning of that particular practice was not inconsistent -- or, I should say, incompatible with NRC's regulatory program.

MR. STEINDLER: I understand that. I also would note that they made that decision before they had the benefit of the most recent discussions with you folks on the subject and I think the most recent clarification and organization of the subject.

So it may well be that while that is true that legally got you off the hook, it may not necessarily have been the correct or the appropriate way to go. I understand that.

MR. SCHWARTZ: Well, the example that you identified, I think that clearly is a very difficult question. That is another example of the kind of issue that we would have to go to the Commission with.

MR. STEINDLER: Yes, I understand that. The concern I have is that there is enough of a basis existing someplace in the Commission's writings so that the Commissions have some basis for saying yes or no. It is in that focus that I am trying to get some clarification as to where you are so at least I understand it, should by some odd chance I encounter a Commissioner walking down the street and I get accosted on the subject, which I wont.

MR. SCHWARTZ: I'm not sure we could either deal with the economic issue any better than we already have at this point because safety and economics sometimes are so interlinked in the eye of the beholder when they say that "cost be darned. This is the way we perceive safety, and we do not want it that way."

That is getting into some areas that maybe within the purview of the Agreement State Program. Flexibility is one we are allowed to give at this point.

May I move to page 8? Thank you, sir.

So, therefore, in the context of our discussion, adequate means an acceptable level of protection of the public health and safety from the radiation hazards associated with the use of byproduct source and special nuclear materials.

Viewgraph 9 follows that an adequate Agreement State Programs means an effectively implemented regulatory program containing elements and program elements as defined in SECY 94-025 with the expanded discussion.

"Regulations, policies, and procedures considered necessary by the Commission to provide an acceptable level of protection of the public health and safety, from the radiation hazards associated with the use of byproduct source and special nuclear materials."

I note one more time that in saying this, that there is still a body of information, procedures and work that still needs to be done to make these words real once the policy is put in place.

On page 10, we have a list of example of program elements and program regulations. These example elements were pretty much derived from three sources. They were derived from the existing Commission policy on what is required to become a new Agreement State, from the existing Commission policy on what the staff has to do with the periodic review of the adequacy and compatibility of

Agreement States.

Then also -- although we are not ready today to talk about details -- we tried to keep these elements as consistent as we could with the integrated materials and Forms Evaluations Program, the common performance indicators, recognizing that that was going on in a parallel effort.

So we tried to look at those three things. These are certainly not an exhaustive list of elements or programmatic, but it is just representative of what we mean by protection. That would mean that the program was designed and administered in a manner to protect the public health and safety of the citizens of the state. Then we can go on. I am not going to get into the details unless you so choose.

With that, then, I could move on to Viewgraph 11. Moving to compatibility now, the staff proposed to the Commission the compatibility component, therefore, would then focus on state action or inaction that would have extra territorial impacts either on other states or on the effectiveness of the national program.

Secondly, that it requires the essentially identical adoption of certain elements of the NRC regulatory program.

On Slide 11 we get into the full definition of what we believe compatibility means. That is the consistency between NRC and Agreement State Regulatory Programs which is needed in order to establish a National Radiation Protection Program for the regulation of byproduct source and special nuclear material which assures an orderly and effective regulatory pattern in the administration of this national program.

Compatibility shall be aimed at ensuring that the flow of interstate commerce is not impeded, that effective communication in the radiation protection field is maintained, that central radiation protection concepts applicable to all licensees are maintained, and that the information needed for this study of trends and radiation protection and other national program needs are ascertained and made available to the NRC staff.

On Viewgraph 13, in this context then, a compatible Agreement State Program means a regulatory program containing the elements -- again, read elements why, -- programmatic elements, regulations, policies and procedures considered necessary by the Commission to effectively implement the term "compatible" as I previously defined it.

On Slide 14, to ensure national uniformity on requirements with extra territorial impacts are necessary for the national program. Existing and new requirements will be subject to the following compatibility tests, to determine if they should be adopted essentially identical, or essentially verbatim, by the Agreement States.

That adoption is necessary to avoid a significant burden on interstate commerce, and that would be uniformity of transportation standards. You can talk about uniformity of seal sourcing device, regulatory programs -- those kinds of things -- that have territorial impacts.

To ensure clear communication of fundamental radiation protection terminology -- byproduct material, total effective dose -- those definitions we have to communicate among ourselves so we understand each other.

To ensure the establishment of common dose limits applicable to all licensees in 10 CFR 20, and to assist the NRC in evaluating the effect in this of the overall national program for radiation protection standards, for radiation protection.

Also we have some MOUs with other Federal agencies where we have to maintain oversight of the Agreement States Program so that we report to them that certain programs are carried out.

On the next viewgraph -- this is Viewgraph 15 -- these example elements were again derived from two sources, one from the existing policy statement on becoming an new Agreement State, and also the existing Commission policy statement on the periodic review of Agreement States.

I wasn't going to go through any one or all of these unless you wanted to get into some details.

But again these are the kinds of things that we think are important to satisfy what the staff is proposing as to what ought to be covered because of the criteria that is established that we are proposing on Viewgraph 14.

MR. STEINDLER: What did you have in mind in the area of reciprocity that was sufficient compelling to be included here?

MR. SCHWARTZ: I think the principal thing that always comes to my mind is the notion of equal regulation with respect to radiographers, that radiographers licensed in one location should have the same treatment, same training, same regulatory program so that his portability is going to go into a NRC state, a non-Agreement State, and that we should have the comfort that he is being regulated the same as he is under the NRC.

MR. STEINDLER: Yet, don't we have at least one state that has increased its requirements for radiographer licensing or training or something?

MR. SCHWARTZ: Yes, sir. I think the example you are referring to is the State of Texas where the State of Texas did add to the training requirements a certification program where they give exams.

I think the NRC regulations has now caught up to that, and they are moving forward in a national certification program similar to the program that the State of Texas started a number of years ago, with a bank of questions that are constantly changing so that you weren't relying on only certification by the licensee management that the radiographers that are going out in the field are adequately trained. They added another requirement for training.

On the next slide, slide 16, the working group and the staff, with some trepidation, went a little beyond what the Commission asked when they directed the staff to develop a policy on compatibility. They asked the staff to develop a policy on compatibility eliminating low-level waste disposal.

With much soul-searching and discussion, it was our view, and Jim Taylor, EDO, agreed, that the staff believed that the proposed policy is consistent with the January 22, 1993, Commission decision on Pennsylvania, and the June 30, 1993, Commission decision on Illinois in that it provides for national consistency for dose standards for all licensees and allows flexibility for a defined class of licensee but still maintaining adequate programs.

In the staff paper that went up we do have a paragraph in there that says that the staff working group and the staff believes that this policy is consistent with the previous decisions of the Commission.

We intend to publish a draft statement in the Federal Register for 90 days once we hear back from the Commission. I guess the Commission is dealing with these issues right now. Sometime in the latter half, I would imagine, of the 90-day comment period staff would conduct another public workshop with the agreement states and the other folks that sat around and hammered it out with us before and try and perfect what it is we have, and then put a final proposed policy statement in place for the Commission to deal with.

That ends the formal presentation. I'm available to respond to any questions.

MR. STEINDLER: Assuming for the moment that the policy stands after you get done with all of your discussions and this is the way it gets implemented, is it your thought that the definition and criteria for adequacy and compatibility are testable, evaluatable as they are currently defined?

MR. SCHWARTZ: I'm sorry.

MR. STEINDLER: Eventually somebody is going to say to the Commission, as the Synar hearing fairly clearly pointed out, how do you know, fellows, that the states are doing the job that you turned over to them?

There has to be some mode of performance evaluation, and that has to rest on your policy statement, I assume. Therefore, the question is, does that policy produce items, definitions, concepts that are testable, evaluatable? Have you gone through that process to see whether or not you can come to the end before you issue this policy?

MR. SCHWARTZ: In the context of evaluation, as Dick alluded to in his opening remarks, there is the parallel effort of the impact program, the common performance indicators. As this was developed, the adequacy issues parallel the measurable, if you want to use measurable sometimes qualitatively, performance of the agreement states, and those same elements you would find as measurable in measuring the performance of the NRC regions in carrying out the same program. That would come together in the materials evaluation program.

We have not yet addressed the elements necessary for compatibility in the common performance indicators. There is really no measure with respect to the performance of the NRC regions on compatibility because NRC has a program that is established by headquarters and the regions carry it out. So I don't think you would find the analog there of the states and the NRC regions for comparability.

Clearly, in the adequacy area, I think we have tried to comport where the staff thinks it's going with respect to common performance indicators and tried to keep compatibility and the impact program kind of moving forward using the same rationale. That is what the goal is.

MR. BANGART: Our current plans maintain as the first part of implementation of common performance indicators a pilot program where we would have an opportunity to get feedback from the agreement states and the regions during the pilot and be able to feed that back into the compatibility policy if it turned out to be unworkable.

MR. STEINDLER: Presumably the common performance indicator system is the one that was described in some document that I've read.

MR. SCHWARTZ: There is a Commission paper. I think it's 94-011.

MR. STEINDLER: The time at which you are going to fix this policy has to somehow be delayed until you get some experience in that pilot program of evaluation. Is that what you intend?

It is going to take you a while to figure out whether or not the common performance indicator pilot program is going to in fact function with adequacy and compatibility as defined herein before you can say, all right, adequacy and compatibility can be cast into a policy in bronze and now we can go ahead and work out the rest of the details. Is that the mechanism that you envision?

MR. BANGART: We can't speak to the timing of the various pieces right now. The pilot program itself is receiving a lot of close detailed scrutiny by the Commission offices on the nature of the pilot. How many of the pieces need to be finalized before we begin the pilot and the timing of the various elements related to the pilot is pretty much up in air at this point in time.

We have proposed, however, that we move forward on essentially two independent tracks. As we originally envisioned, the compatibility policy would not be finalized until after the pilot was well under way, and we would have had to do the pilot using the old compatibility policy. That was our proposal in the paper.

MR. STEINDLER: I guess most of my commentary would have been on the common performance indicators. I have a fairly fundamental problem with that, but I'll reserve that for some other time.

MR. SCHWARTZ: I appreciate that, Mr. Chairman.

MR. HINZE: Do I understand correctly that the Division 1 and Division 2 requirements are going to be eliminated?

MR. SCHWARTZ: That's correct.

MR. HINZE: On page 11, the compatibility component requires the essential identical adoption of certain elements. This is presumably the Division 1 requirements.

MR. SCHWARTZ: It could be based on the four criteria on extraterritorial impacts. I can't say yes or no at this point, but some of the Division 1 requirements may not fall out that way.

We are also proposing not only regulations, but we are also discussing programmatic elements. That's why I raised the issue of sealed source and device reviews.

In addition to just regulations, we are also proposing to the Commission that the way NRC handles a particular -- like sealed source and device reviews. We have a mechanical engineer that reviews devices, and so on and so forth -- that we would expect the states under compatibility to use essentially identical reviews. The same ANSI standards, of course, but the same staff level of expertise so that we are sure that devices that are being used nationwide that are being manufactured in an agreement state have the same level of assurance that we believe we are providing in the NRC program. So that's another wrinkle.

MR. POMEROY: Would you say that that statement that you just made could be applied analogously for low-level waste facilities, that is, that they would receive the same level of review as the NRC might perform with a non-agreement state if a non-agreement state came in for low-level waste facility?

MR. SCHWARTZ: I hadn't really thought about it that way. I think that would be a candidate. That would be difficult. There are certain states that come in and ask us for what they call technical assistance, where they may not nave a particular expertise. We ask the states to do their work first and then come into the NRC and then we provide technical assistance to the states as to whether they did the job adequately.

But I hadn't really thought about looking at all of the different rationale and components. It is not a marketed product that is going across state lines. It's something that is going to be fixed in one particular location, but it is somethin, :hat maybe should be addressed.

MR. STEINDLER: Except in the compacts. The compacts ferry stuff across state lines.

MR. SCHWARTZ: Right.

MR. BANGART: I think what we certainly would want to be assured of was that the level of safety that was provided as part of the review process would be at least as good as that provided by the NRC review. It may be that they could use a more simplistic model, but it would be sufficiently conservative and still they would able to come to a licensing conclusion. That is probably a situation where, using this policy, we would find the agreement state program acceptable.

MR. GARRICK: If I dropped out of the sky and had looked at this for the first time and glanced over and asked myself which of the items could possibly lead to some of the more difficult issues with respect to decision-making, I might jump on page 5, the last item.

MR. SCHWARTZ: Page 5 of the viewgraphs?

MR. GARRICK: Yes.

While we are pretty specific on the matter of strict adherence to radiation standards, doesn't the last item give the opportunity to undermine that through some sort of a crossover process? I don't know exactly how, but it might take place if we develop these for mixed waste. For example, where the judgment would be made that because of the environmental effect of the toxic materials but they are really concerned about being able to reduce the standard on radiation, could they not use the toxicity argument to actually get around the strict adherence requirement on radiation standard?

That just happens to be a detail that I thought of.

MR. SCHWARTZ: Slide 5 is really what we heard from the states and the community. But your point is well taken. Yes, I can see the states making judgments based not only on non-radioactive toxicity, but the states also have responsibility for non-AEA radiation, NORM, NARM and x-rays. So they have to take all of that into the formula in making a decision about their constituents, and we don't. So they would have to look at the total burden of radiation on their constituents other than AEA materials and the environment.

MR. GARRICK: There must have been a lot of discussion about the flexibility issue having to do with being able to adopt more stringent requirements in the environmental area. I'm surprised that that is as loose as it is.

MR. STEINDLER: Let me raise one other issue with you. One of the attributes of both compatibility and adequacy as you have defined it is that they are near-term measures or indicators or issues. In light of the long lead time, both bureaucratic as well as otherwise, it takes to remediate the situation in a state, it seems to me that the Commission would have an obligation to provide for itself some early warning indicators which if they don't get changed or improved or modified would be a reasonable cause to have concern that a program may deteriorate fairly quickly.

There is nothing in either the definition of adequacy or compatibility that allows for an evaluation process that I can see consistent with those definitions that looks into the future far enough based on experience or intuition about what makes a good program last as a good program.

My question is, if that analysis is correct, aren't you folks putting on the Commission itself the burden of trying to anticipate from information that AEOD gathers, or whoever collects the information, the deterioration of a program based on fairly snaky grounds?

More importantly, isn't it likely that if a state program is deemed unsatisfactory by the Office of State Programs and Dick comes wandering up to the Commission and says, hey guys, we've got to do something about this, at that stage of the game you are already well into a deterioration process, you are on a downward slope, and at that point one could argue that the health and safety of the public could well be in the process of being compromised until the NRC's more controlled operation takes effect and brings the activities back into compliance? Why were kind of forward looking issues not included in here so that they would be part of the c. ain?

MR. SCHWARTZ: My view is that that foresight was really put into the integrated materials performance evaluation program, SECY 94-011, through the process of evaluating each state and then having a management review board that would look at not only the numbers, not only the indicators, but look at the history of the program of previous reviews and try and ferret out is there an early indication of a state falling into disrepair. As many of us have seen, the states falling into disrepair are the smaller states where staff is so critical that when you lose one or two people it's an immediate thing and the state is in trouble immediately. That's a very easy indicator.

How long we are going to aid the state, help the state or start a proceeding where we have to make a determination that the state is not running a program in the best interest of the protection of the public health and safety is still a process that is being worked on in parallel with common performance indicators policy and looking at the common performance indicators as the implementation of this policy and the evaluation that has to be done in order to say, yes, it's time to move to either take a program back or to state that a program is in disrepair and lay out certain action plans.

Some of the things are slow developing with respect to a state being in disrepair but most of them are pretty self-evident in budget, in trained staff and in numbers of staff. My experience is that you see that right away and you should know it and not wait for a biennial review when we have to go out and do a review, but when our Regional State Agreements officers know that they have lost individuals, we should take action then and inform the Commission and give them advice based on whatever we have at that time.

MR. STEINDLER: As I read 011, I was looking for some kind of indication that that future-looking evaluation process was there. I didn't find it. Maybe I didn't read it right.

I would have a couple other comments. One, I personally am concerned about a review every two years, because things can go to hell in a handcart a lot faster than that.

Secondly, it seemed to me that in the policy statement itself there ought to be some kind of an indication that the Commission is in fact looking at the longer range aspect of an agreement states program in the context of compatibility as well as adequacy, particularly adequacy, and thereby serving notice on the states that this is not a snapshot in time today or perhaps even yesterday but is going to be a snapshot that extends into the future in some fashion or another because there is a long-term commitment for the protection of the health and safety of the public.

The evaluation process, the major problem I have with it is that it tends to focus not on the adequacy program elements but on the compatibility program elements, and they are second order, in my judgment, to the immediate health and safety issues that normally arise. You mentioned the sealed source approach. I could not understand the rationale for pulling those out because the regions have a separate role. But we are not here to discuss it, I'm told.

Anyway, that was the concern that I had and it seemed to me it might be worthwhile putting a notice in for the states saying, look, we're going to look at you guys for the longer haul, because that is what you are in for; you're in for the long haul and we want to make sure that that long haul is at least level if not up, but if you let it deteriorate, we are going to watch it.

That may be the wrong reading of what you have here.

MR. BANGART: I think your reading of the paper is correct. There are many additional guidance and procedural documents that we have not yet created that will support the paper that you read.

The concept of the team that is described in the paper is that it's composed of senior experienced people and that they are not just going to have a number of indicators to get data on it and do a check mark, yes, no, they're okay, not okay, but to use a judgment as they discover findings that might be of concern during that agreement period, to follow their nose much like an AIT or an IIT does. That's the concept that we see the team using in the review so that it's not just limited to a set of formal indicators but they are supposed to use their experience and intelligence, and if they see signs of a problem, to dig deeper into that particular area. I think that is consistent with what you are talking about.

MR. STEINDLER: Why did you pull a separate review board in to do the same job that you folks have been doing all along?

MR. BANGART: It was go give the broader perspective to the final determination. That deliberation would be much like a SALP-like discussion where you would bring into consideration before the agency makes a final finding things like, is this just likely to be the tip of iceberg in the sense that the program is down trending? You might make a more serious call then in terms of the final determination. Or, has the state itself identified the problem? Do they have a corrective action plan in place, and is the program turning around? They would be able to factor in that kind of information and use that to make the final determination.

If you just looked at the formal indicators, you might have two relatively identical sets of findings based on just the indicators, but based on the additional information, the management review board might call one program adequate and the other program marginally adequate, depending on what is happening in other areas: Are they in control of their own fate or is it out of control?

MR. STEINDLER: My problem with the management review board is it looked like it was shifting responsibility from the place where I thought it belonged, namely, in your office, to an outside group who, although senior people and experienced, it seems to me you can call on for advice without having to formulate a separate group. It wasn't clear who that separate group reports to and why it has been pulled away from the place that runs all the rest of the aspects of the state program, which is your responsibility. But that's a decision you folks make on how you want to run the shop more than anything else.

MR. HINZE: When I looked at that, what investigative powers they would have was the first question that came to my mind.

MR. STEINDLER: I didn't see very many. I think they were basically responding to the information provided to them by the AEOD and the Office of State Programs.

MR. BANGART: That's right.

MR. SCHWARTZ: And the review team.

MR. STEINDLER: And the review team.

MR. BANGART: The board itself would not do anything. They would rely on the input that they received from the team, and the team would provide their own recommendation for the review board. They would not just give findings without a recommendation.

MS. MAUPIN: I would like to clarify one thing on the snapshot. Presently I am the project manager over the review letters. We too have the problem in just taking a snapshot or this is the condition as it exists at that particular time. Management has decided to take a more long-term view of the Agreement States program. When the letter goes out we don't just assess at that "time" we're out there, but any other problems that might come up before that letter goes out.

I would like to also interject that we do go out in the interim on a visit and look at any other conditions that might exist in the states. So we are out there on an annual basis.

MR. STEINDLER: I assume that review is less intensive than the biennial.

MS. MAUPIN: On the biennial we have 102 questions on the questionnaire that the state has to fill out in terms of providing information back to us. The staff will continue to look at those 30 indicators to make sure that the states are continuing to be adequate and compatible.

MR. POMEROY: Do you see the teams in the future being essentially the same size and composition as the teams have been in the past?

MR. SCHWARTZ: The proposal now is to have teams that are larger than they were in the past and also augmented, as we have in the past, with specialists. If a state has a low-level waste disposal program, we will send a specialist out for that. Or Steve Bangart would go out because there's a sealed source and device. For California and others that have a robust sealed source and device program we'll have a specialist. But the teams are larger because we expect to go more in depth in a lot of areas.

MR. POMEROY: That is what I was envisioning if you get into the low-level waste area. Once you get into that area, it seems to me that if we were doing the licensing we would have a lot of people, hydrologists, geologists, and so forth, looking at our low-level facility, and even a one or more person augmentation might not be sufficient to overlook the state's whole program in the agreement states case.

MR. SCHWARTZ: Right.

MR. STEINDLER: Any other questions?

MR. FOLAND: It seems to me that this policy must have some implications for states that are not agreement states. For example, it might be advantageous for some states now to try to become agreement states. What are the ramifications of that in the future?

MR. SCHWARTZ: We did recognize that a new policy on adequacy and compatibility could have an impact on emerging agreement states. That's why at these workshops we did have people from states who were not agreement states as well. Clearly, the folks who we are dealing with today, Pennsylvania, Ohio, Massachusetts, Oklahoma, who have announced that they would like to become agreements states, I'm sure they are concerned that the game is changing at the same time they are trying to meet and staff up and get their regulations.

Yes, there is an impact. How to ameliorate that, I can't offer anything, because at some point in time all the agreement states will eventually have to comport with the new policy. How that will phase in is something that still has to be looked at, particularly if we lay on more requirements through compatibility.

There is the notion I will throw out that perhaps we have to look at the agreements themselves, each of the agreements since 1962. Some of them are different from the ones that we are signing today. As programs change and as policies change there may have to be a wholesale look at the existing agreements that we have in place today to see if they need amending.

I think you raise a very good point. Yes, the states who are in the process now are saying, what are the rules of the game, what is it that we have to comply with, what kind of a program do I have to put together that will satisfy the adequacy and compatibility policy?

You're right. It is something that needs doing.

MR. STEINDLER: Any other comments?

[No response.]

MR. STEINDLER: Thank you very much for coming. We appreciate your expounding on a complex subject.

This brings to a close the regular portion of our meeting. We will stay in open by unrecorded executive session for a few minutes to do a little planning on what we have heard today and what we should do about it.

I want to thank the recorder for his patience and, I trust, his accuracy. With that, let me close the meeting and take a five-minute recess.

[Whereupon at 5:12 p.m. the recorded portion of the meeting was concluded.]

REPORTER'S CERTIFICATE

This is to certify that the attached proceedings before the United States Nuclear Regulatory Commission
in the matter of:

NAME OF PROCEEDING: 61st ACNW Meeting

DOCKET NUMBER:

PLACE OF PROCEEDING: Bethesda, MD

were held as herein appears, and that this is the original transcript thereof for the file of the United States Nuclear Regulatory Commission taken by me and thereafter reduced to typewriting by me or under the direction of the court reporting company, and that the transcript is a true and accurate record of the foregoing proceedings.

Michael Paulus

Official Reporter
Ann Riley & Associates, Ltd.

PRESENTATION TO THE ADVISORY COMMITTEE ON NUCLEAR WASTE

STATUS REPORT ON STAFF ACTIVITIES IN THE TOPICAL AREA OF IGNEOUS ACTIVITY

PRESENTER INFORMATION

NMSS Activities Related to Igneous Activity

Keith I. McConnell, Section Leader
Geology/Geophysics Section
Geology and Engineering Branch
HLWM (504-2532)

ACNW 23FEB94

OUTLINE OF PRESENTATION

- <u>REACTIVE ACTIVITIES</u>:
  Summary of Staff Review Activities Related to Igneous Activity
  1. SCP and Study Plan Reviews:
  2. Review of LANL "Volcanism Status Report:"

- <u>PROACTIVE ACTIVITIES</u>:
  1) Iterative Performance Assessment Phase 2
  2) License Application Review Plans for Igneous Activity
     A. Many review plans under development: Geologic System Description, other PACs and FACs, design review plans, performance assessment review plans
     B. One completed review plan for Potentially Adverse Condition: Igneous activity since the start of the Quaternary Period

ACNW 02/23/94

STUDY PLAN REVIEWS

- Thirty-six out of thirty-nine SCP and Study plan Comments and Questions exist as Open-Items

  22 Comments (3/19)

  14 Questions (2/12)

- Three Study Plan Reviews Completed to Date, One in Progress:

  8.3.1.8.1.1 Probability Of Magmatic Disruption of Site R1&R2
  8.3.1.8.2.1 Analysis of Waste Package Rupture...
  8.3.1.8.5.1 Characteristics of Volcanic Features

  8.3.1.8.1.2 Physical Processes of Magmatism...

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STUDY PLAN REVIEWS

- CNWRA evaluations of study plans provide a significant part of the basis for Staff reviews.
- Comments fall into five major categories summarized by August 18, 1993 Holonich to Shelor letter:

  Adequacy of planned testing (18)
  Use of "tripartite" probability (6)
  Unsupported conclusions (4)
  Use of only homogeneous poissonian models (1)
  Consideration of Uncertainty (7)

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LANL Volcanism Status Report Review

- Staff, assisted by CNWRA, completed review 05/93
- NRC/DOE Technical Exchange 06/06/93
- NRC letter to DOE (Holonich to Shelor, 8/18/93) noting five major areas of concern. (Also transmitted CNWRA review of status report)
    - Adequacy of planned testing
    - Use of Tripartite probability
    - Poorly supported conclusions
    - Use of only homogeneous poissonian models
    - Consideration of uncertainty
- DOE letter responding to NRC letter (11/23/93); staff concerns remain unresolved.

ITERATIVE PERFORMANCE ASSESSMENT PHASE 2

- Phase 2 considered the topic of Igneous Activity. Purpose was to develop the assessment capability to evaluate igneous activity in terms of total system performance.

- Effort was considered a first step, was based on limited site data, and used numerous simplifying assumptions regarding probability and consequence.

- Results of Phase 2 effort showed that the contribution to the CCDF are low probability/high consequence:

  - increases normalized release by about 15x EPA limit with direct release from volcanic cones
  - increase to release in liquid or gaseous pathway caused by premature failure of canisters by intersecting dikes was insignificant.

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LICENSE APPLICATION REVIEW PLANS

- Evidence of Quaternary igneous activity and the projection of that activity will be a component of many review plans including the Geologic System Description, other PAC and FAC review plans, design and performance review plans.

- Additional Key Technical Uncertainties related to igneous activity will be developed under these additional review plans. Many of these uncertainties may require the development of independent review capabilities including research.

LICENSE APPLICATION REVIEW PLAN
Quaternary Igneous Activity

- Addresses only the PAC concerning Evidence of Quaternary Igneous Activity
- Does not address probability of igneous activity in the future or consequences of an event. This will be the subject of other review plans.
- Identified three Key Technical Uncertainties with consideration of Quaternary Igneous Activity:

  1) Poor Resolution of Exploration techniques to detect and evaluate igneous features (Type 4)
  2) Inability to Sample Igneous Features (Type 5)
  3) Development and use of alternative tectonic models as related to igneous activity (Type 5)

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User Needs
Igneous Activity

- Address the presence of Quaternary Igneous Activity, the likelihood of future events, and possible consequences.
- Were developed prior to identification of KTUs
- Address issues broader than that in existing KTUs
- Will be modified following identification of all KTUs related to igneous activity.

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User Needs
Igneous Activity

601 - Evaluation of mechanisms and processes that control the location of igneous features

602 - Evaluation of past temporal and spatial patterns of igneous activity

603 - Evaluation of effects of igneous activity on on groundwater flow

604 - Evaluation of theories of multiple volcanic eruptions

605 - Evaluation of age-determination techniques in volcanic terrains

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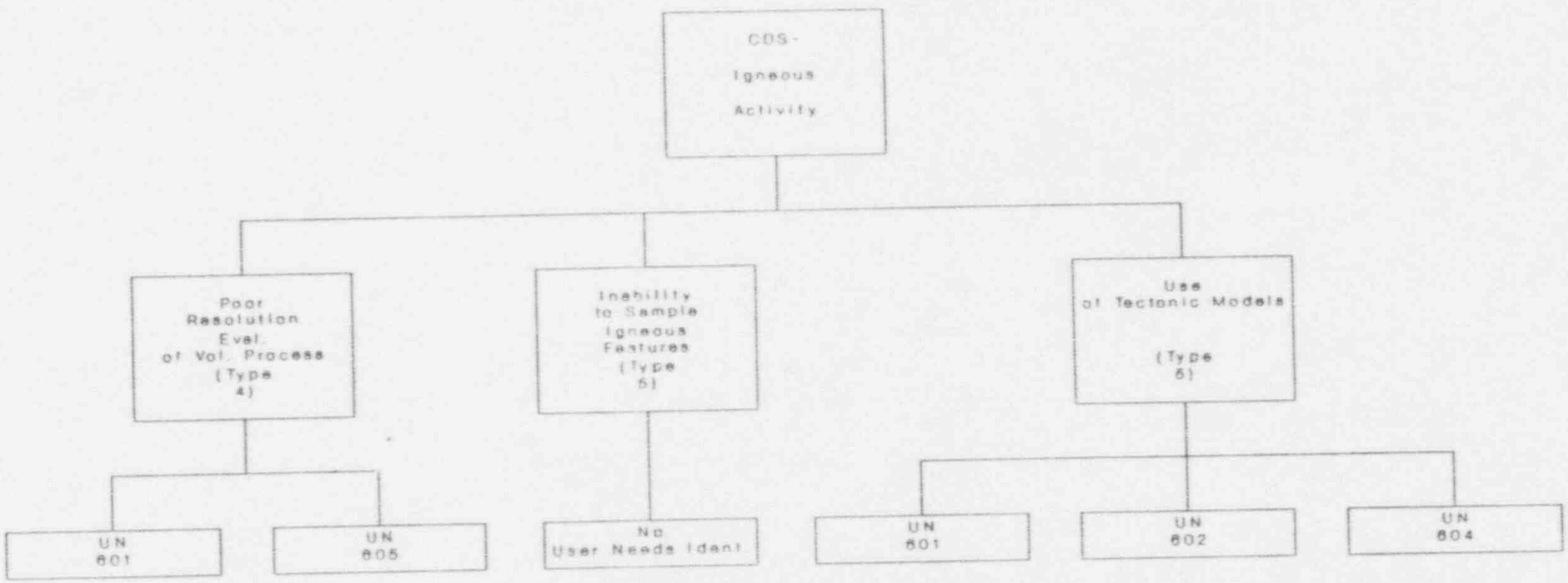
Flowdown Related to Igneous Activity PAC
NMSS/RES/CNWRA Activities



STATUS OF CNWRA PROBABILITY AND CONSEQUENCE STUDIES OF POTENTIAL MAGMATIC DISRUPTION OF THE CANDIDATE HLW REPOSITORY

FIN B-6644

NRC Project Manager: Linda A. Kovach

PRESENTED AT THE
ACNW MEETING ON VOLCANISM RESEARCH
FEBRUARY, 1994

Investigators:
Charles B. Connor, Brittain E. Hill
Gerry L. Stirewalt, Stephen R. Young

CNWRA Project Manager: H. Lawrence McKague

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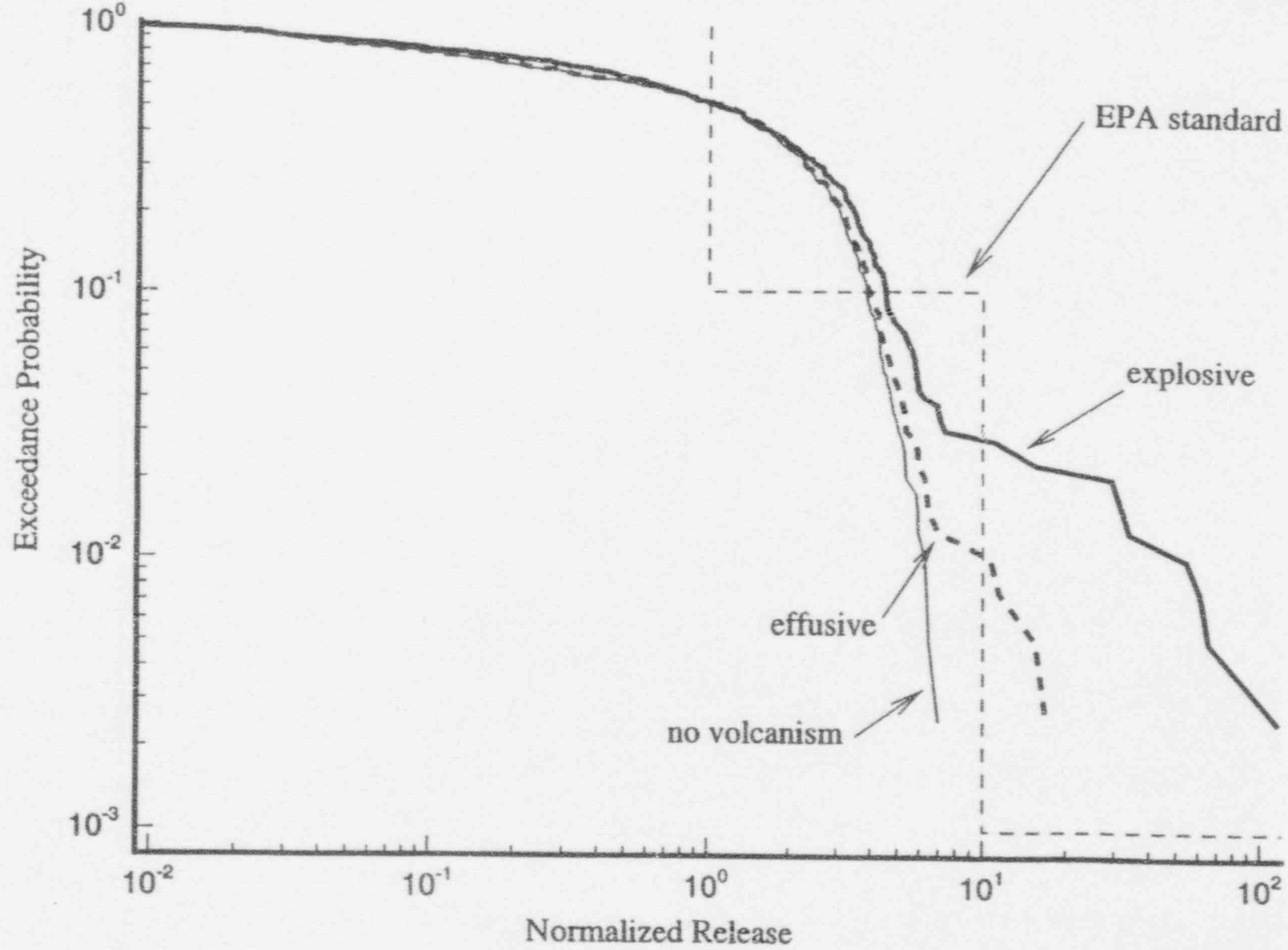

Exceedance Probability
10^0
10^-1
10^-2
10^-3
10^-2
10^-1
10^0
10^1
10^2
Normalized Release
EPA standard
explosive
effusive
no volcanism

ACNW294\2

OUTLINE

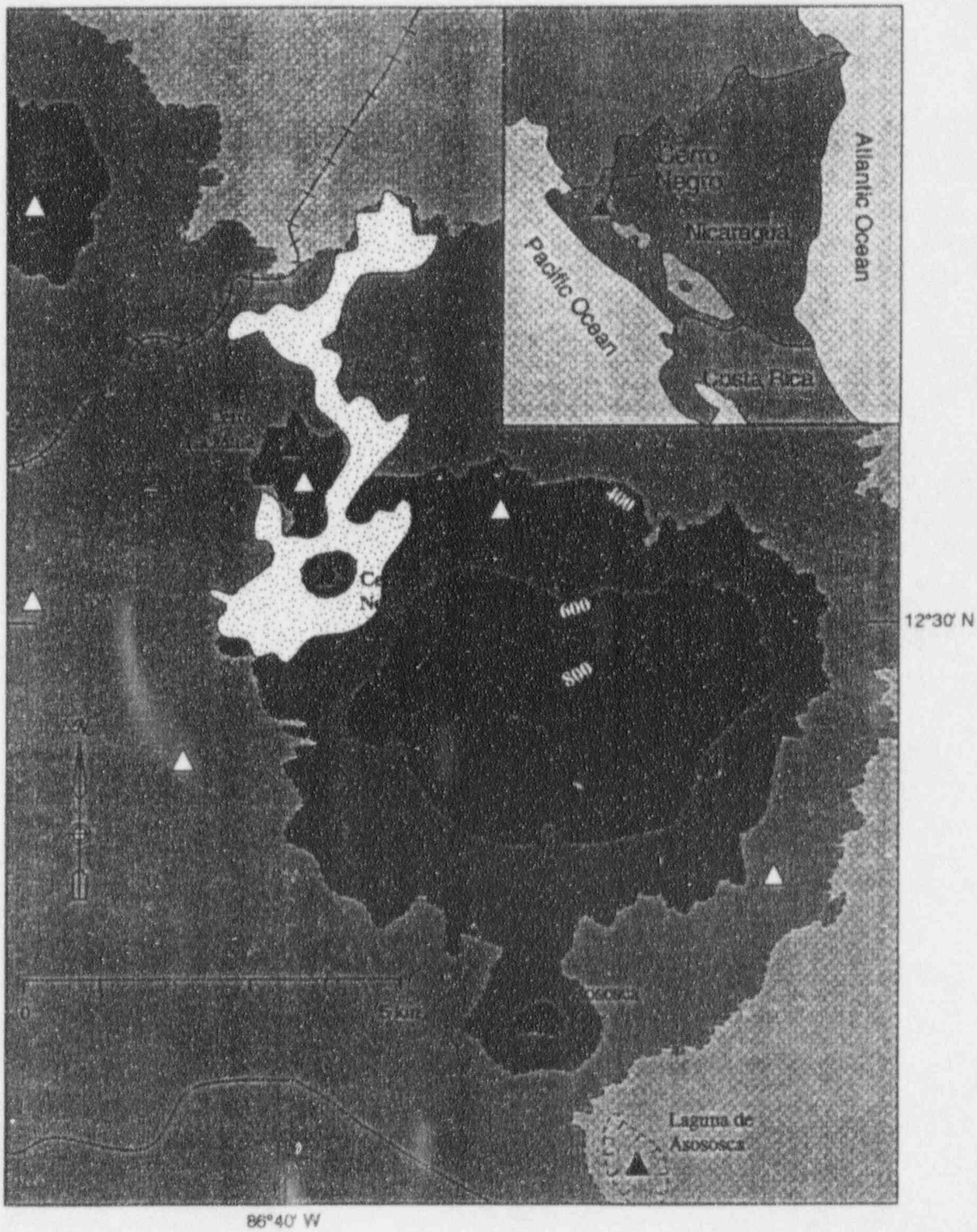
CURRENT STATUS OF CONSEQUENCE STUDIES

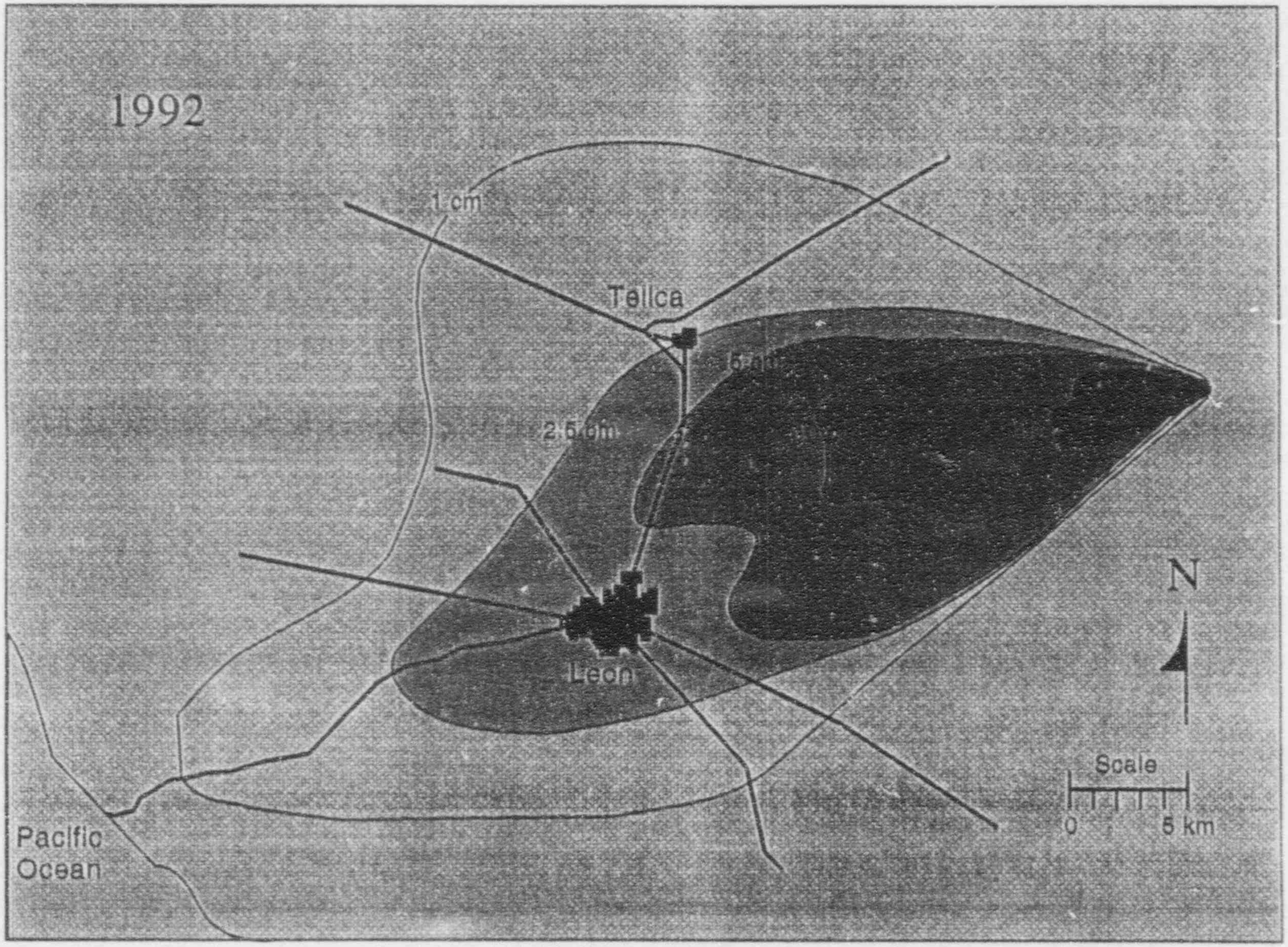
- Learning about eruption mechanics from monitored eruptions
- Learning about heat and mass transfer at cooling cinder cones
- Conceptual model development and impact on probability

CURRENT STATUS OF PROBABILITY STUDIES

- Estimating Recurrence Rate
- Describing Vent Distribution
- Nonhomogeneous Poisson Models
- Markov Models
- Getting to the Geologic Basis

ACNW29414


Cerro
Negro
Nicaragua
Pacific Ocean
Atlantic Ocean
Costa Rica
400
600
800
0
Laguna de
Asososca
12°30' N
86°40' W



ACNW294\5

ERUPTION MECHANICS

Eruption mechanics can be characterized using a broad range of measures if direct observations of the eruptions are made. Cerro Negro (1992):

- Observed column height (first 18 hr): 7–8 km
- Observed column height (second phase): 3.5–4.0 km
- Sustained ash column
- Ash accumulation in Leon (20 km from C.N. after 18 hr): 4 cm
- Total Ash accumulation in Leon: 5 cm
- Total ash volume: 0.06 km^3 (about 0.03 km^3 DRE)

Assuming that the density of the magma is about 2800 kg m^{-3} and accumulation rates in Leon are representative, the effusion rate during the initial 18 hr of 1992 activity was 300–500 $m^3 s^{-1}$.

ERUPTION MECHANICS

Given this effusion rate, steady thermal energy release is calculated based on a simple, empirical approach (Wilson et al., 1978):

$$Q = \rho v s (T_m - T_a) F$$

ρ	=	2800 kg m^{-3}
V	=	300 - 500 $m^3 s^{-1}$
S	=	1.1×10^3 J kg^{-1} °K^{-1}
Tm	=	1050 °C
Ta	=	0 °C
F	=	0.7 - 1.0 (efficiency of heat transfer)
Q	=	6.7×10^{11} to 1.6×10^{12} W during the initial phase of the eruption.

Given Q, column height is estimated by:

$$H = 8.2\ Q^{0.35}$$

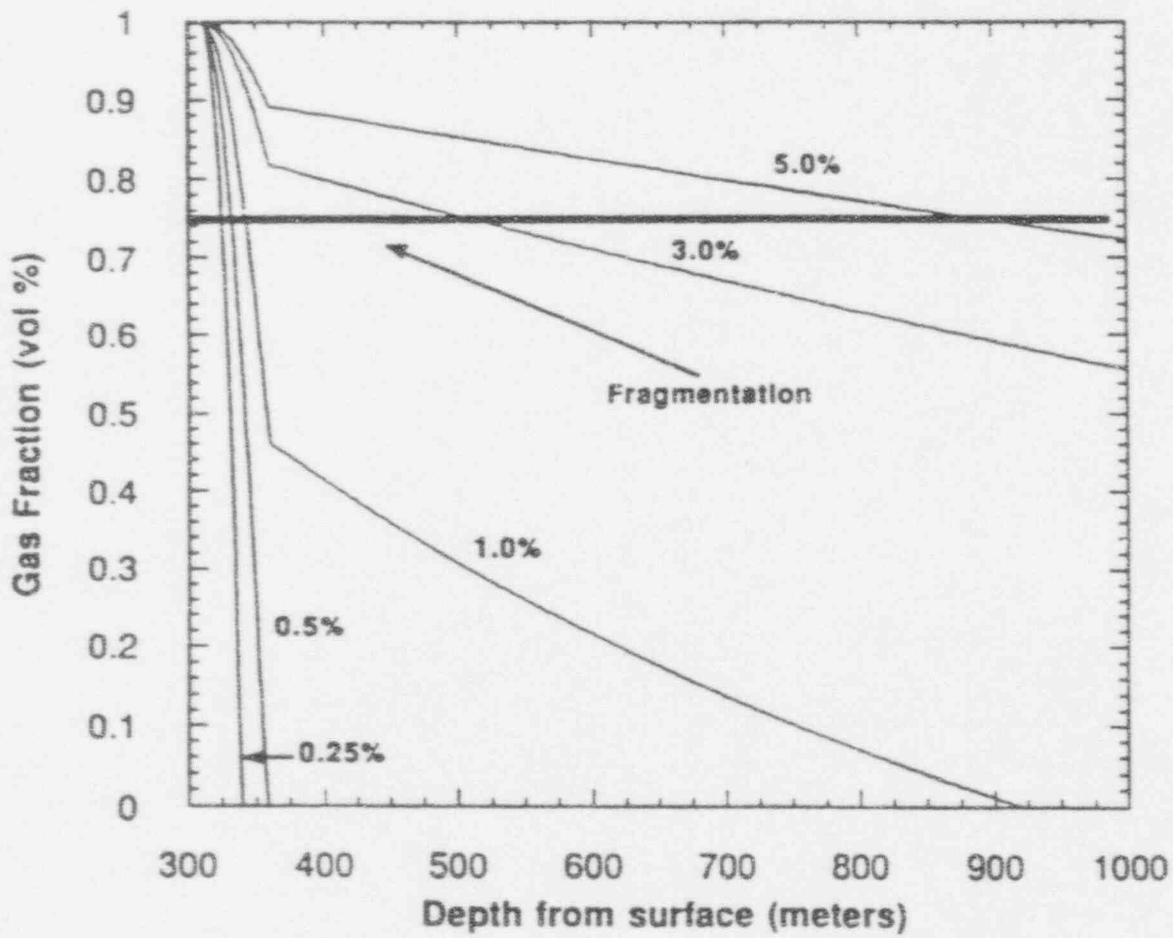
or H = 7.4 to 9 km, in excellent agreement with observed column height. A sustained column and steady energy release describe the initial phase of the eruption well.

ERUPTION MECHANICS

How is this information used?

- Direct Modification of PA models
- Comparison of measured parameters
  - volatile content
  - mineral assemblages
  - bubble size distribution
- Testing and development of numeric models

Comparison with modern basaltic eruptions provides the best, most defendable means of evaluating eruptive processes in the YMR.



Gas Fraction (vol %)
Depth from surface (meters)
5.0%
3.0%
1.0%
0.5%
0.25%
Fragmentation
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
300
400
500
600
700
800
900
1000

AC.NW294\9

COOLING CINDER CONES

Volcano Degassing is a long-term Process

Volcano Degassing may influence a much larger area than is influenced by direct disruption

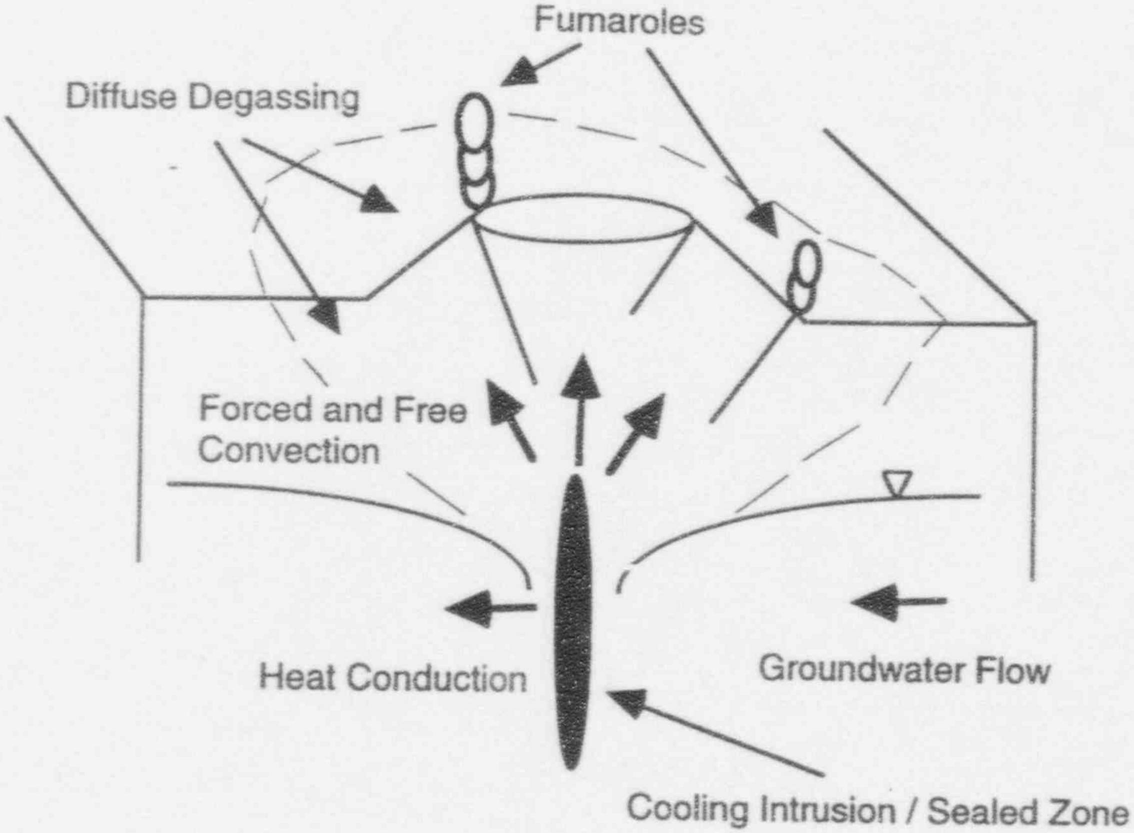
Impact of Degassing related to:

- Change in transport rates in the geologic environment
- Accelerated corrosion of the waste package
- Change in the mechanical strength of rocks

COOLING CINDER CONES

STUDIES WILL INCLUDE:

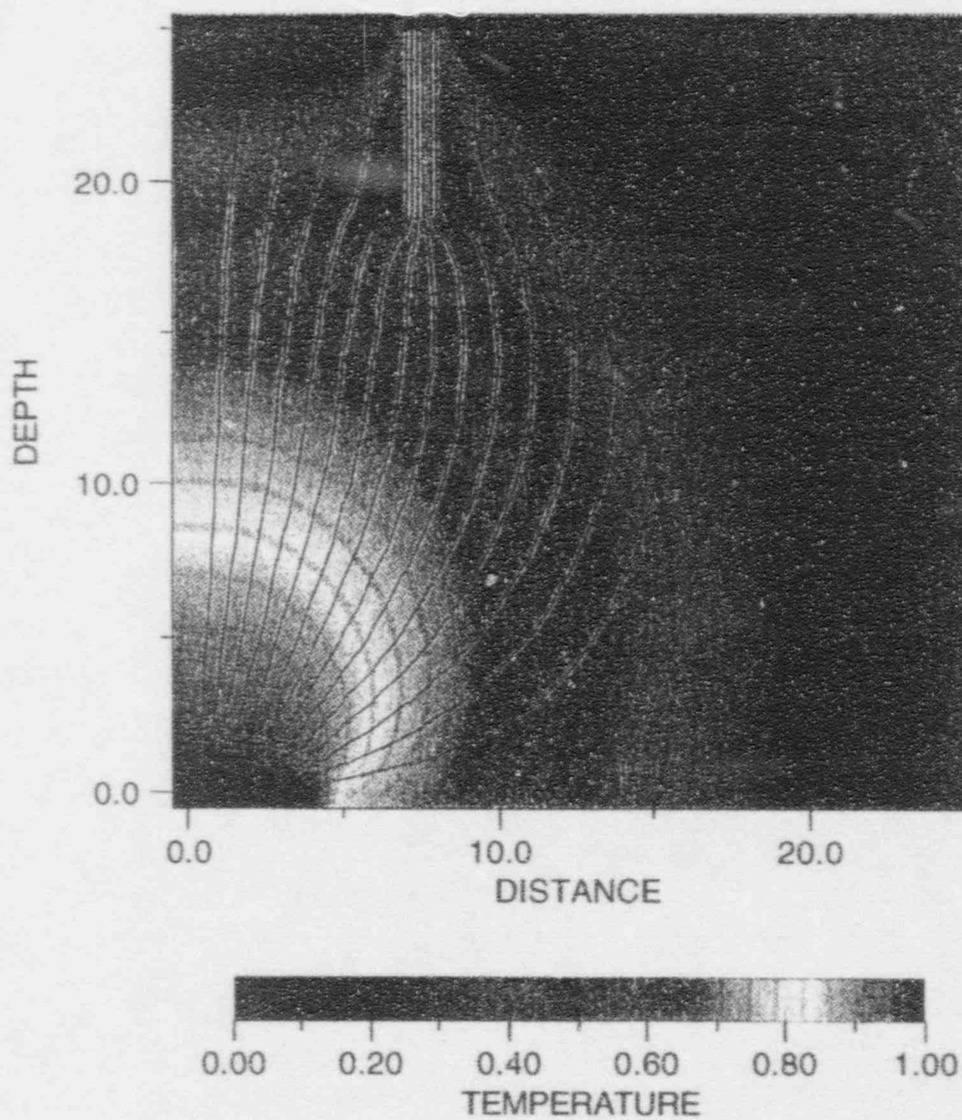
- Field Studies
  - Chemistry, Temperature, and Mass Flow of Gases
  - Duration of Anomalous Heat and Mass Transfer
  - Areal Extent of Degassing
- Model Development
  - Conceptual Model Development
  - Numerical Model of Heat and Mass Transfer
  - Integration into PA



Fumaroles
Diffuse Degassing
Forced and Free Convection
Heat Conduction
Groundwater Flow
Cooling Intrusion / Sealed Zone

ACNW294\12

Boundary Value Solution for Conceptual Degassing by Forced and Free Convection



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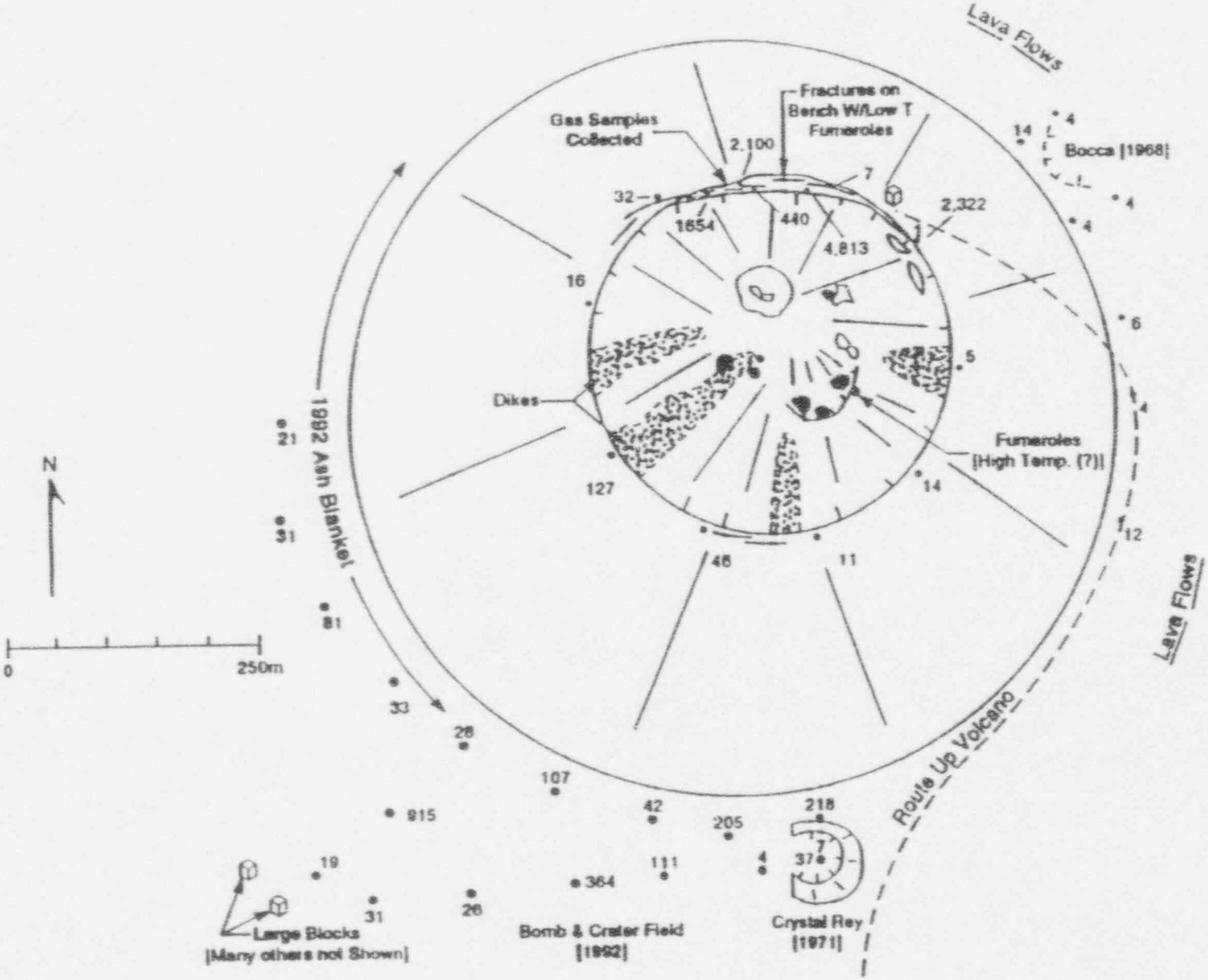


Lava Flows
Fractures on Bench W/Low T Fumaroles
Gas Samples Collected
2,100
14
4
Bocca [1968]
7
32
1654
440
4,813
2,322
4
4
16
6
5
Dikes
1992 Ash Blanket
21
N
31
81
0
250m
33
28
Fumaroles [High Temp. (?)]
14
127
46
11
12
Lava Flows
Route Up Volcano
107
915
42
205
218
19
111
4
37
31
26
364
Large Blocks [Many others not Shown]
Bomb & Crater Field [1992]
Crystal Rey [1971]

ACNW294\14

COOLING CINDER CONES

How is this information used?

- Direct Modification of PA Models
- Use of VTOUGH code to model impact on Hydrologic Setting
- Use of EQ6 to model impact on Geochemical Transport

PROBABILITY MODELS

- Choosing Appropriate Models
- Nonhomogeneous Poisson Model
- Markov Model

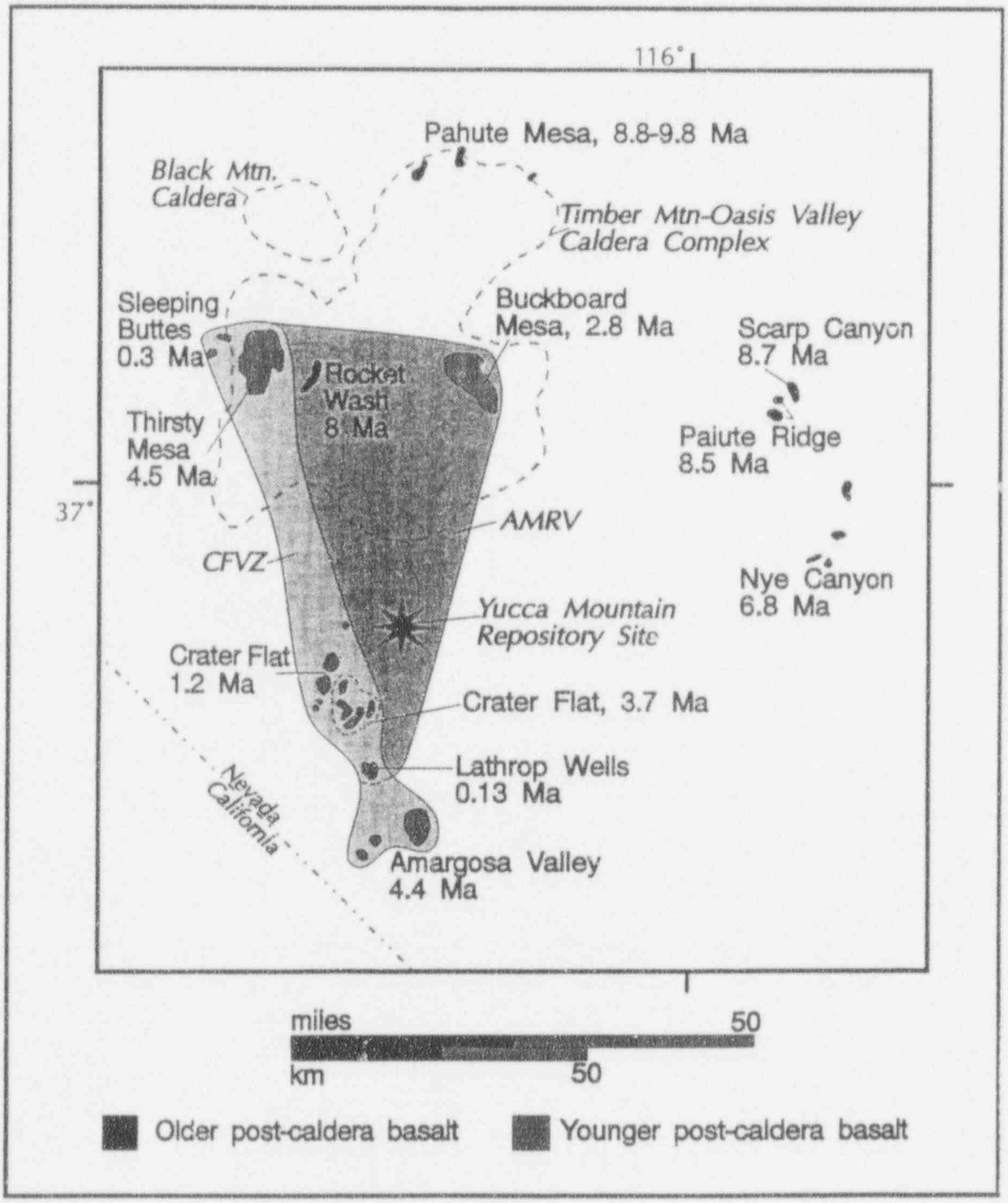
CHOOSING APPROPRIATE PROBABILITY MODELS
(ALL PROBABILITY MODELS ARE NOT ALIKE!)

CRITERIA

- Models must account for observed spatial and temporal patterns in cinder cone volcanism

- There must be a physical basis for parameter selection

- Models must be consistent with geologic and geophysical information


116°
Pahute Mesa, 8.8-9.8 Ma
Black Mtn. Caldera
Timber Mtn-Oasis Valley Caldera Complex
Sleeping Buttes 0.3 Ma
Buckboard Mesa, 2.8 Ma
Scarp Canyon 8.7 Ma
Rocket Wash 8 Ma
Thirsty Mesa 4.5 Ma
Paiute Ridge 8.5 Ma
37°
AMRV
CFVZ
Nye Canyon 6.8 Ma
Yucca Mountain Repository Site
Crater Flat 1.2 Ma
Crater Flat, 3.7 Ma
Nevada
California
Lathrop Wells 0.13 Ma
Amargosa Valley 4.4 Ma
miles
50
km
50
Older post-caldera basalt
Younger post-caldera basalt

PROBABILITY MODELS

Volcanoes form spatial clusters in the YMR (Hopkins F-test; Clark-Evans test, K-function) with 99% confidence. Differences in ages of near-neighbor cinder cones are less than expected (99% confidence, paired Student t-test).

- Recurrence rate must vary within the YMR
- Homogeneous Poisson models do not adequately describe volcano distribution

Homogeneous Poisson models will overestimate the probability of volcanism in some parts of the YMR, far from Quaternary volcanoes, and underestimate the probability of volcanism close to late Quaternary Crater Flat volcanoes.

PROBABILITY MODELS

Estimating Recurrence Rate in a Nonhomogeneous Model

One approach is to use near neighbors: $\lambda_r = \dfrac{m}{\sum_{i=1}^{m} u_i t_i}$

where: λ_r is the recurrence rate at a point
t_i is the time since the formation of the volcano
and $u_i t_i$ is minimum for the nearest *m* neighbors

The number of the near neighbors can be constrained by integrating the recurrence rate over the entire region to estimate the recurrence rate in the YMR, λ_t:

$$\lambda_t = \sum_{i=0}^{m} \sum_{j=0}^{n} \lambda_r (i,j) \Delta x \Delta y$$

PROBABILITY MODELS

Using a spatially varying recurrence rate, it is possible to estimate the probability of a new volcano forming within or near the repository block:

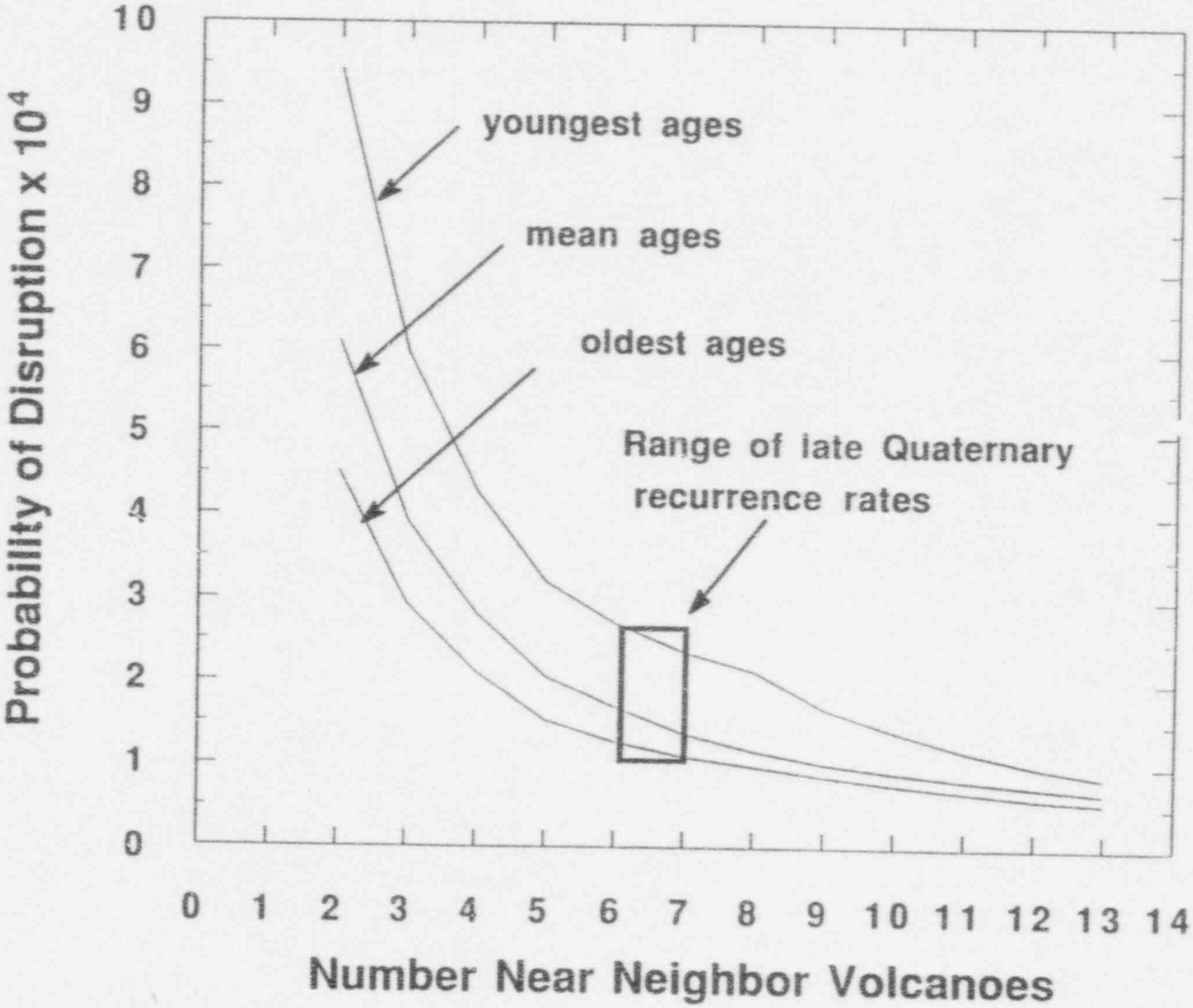
$$P\,[N \geq 1] = 1 - \exp\left[-t\int_x\int_y \lambda_r(x,y)\; dy dx\right]$$

or

$$P[N \geq 1] = 1 - \exp\left[-t\sum_a \lambda_r \Delta x \Delta y\right]$$

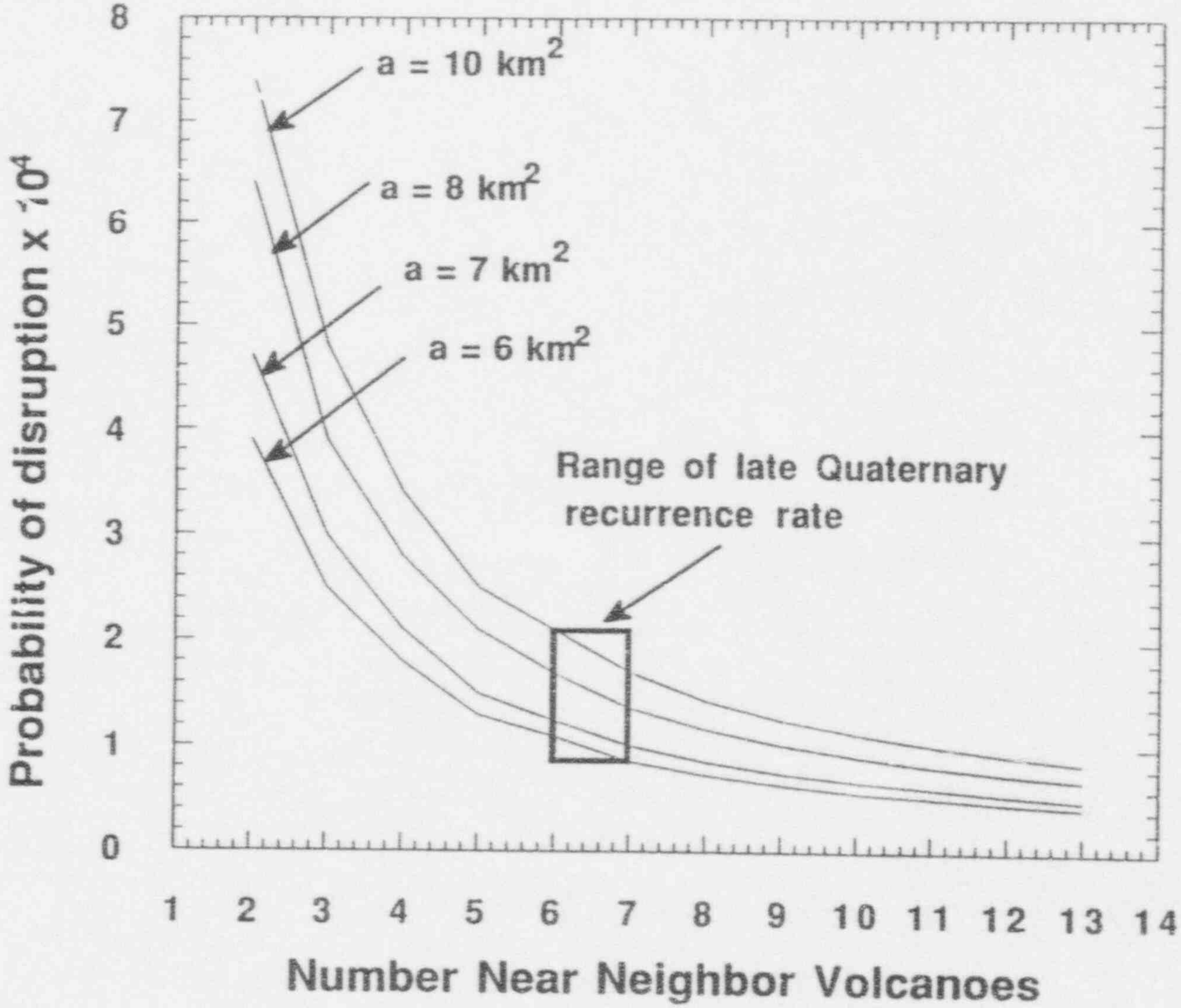
where

t = 10,000 years
λ_r is the expected recurrence rate at point x,y
a is the area of the repository



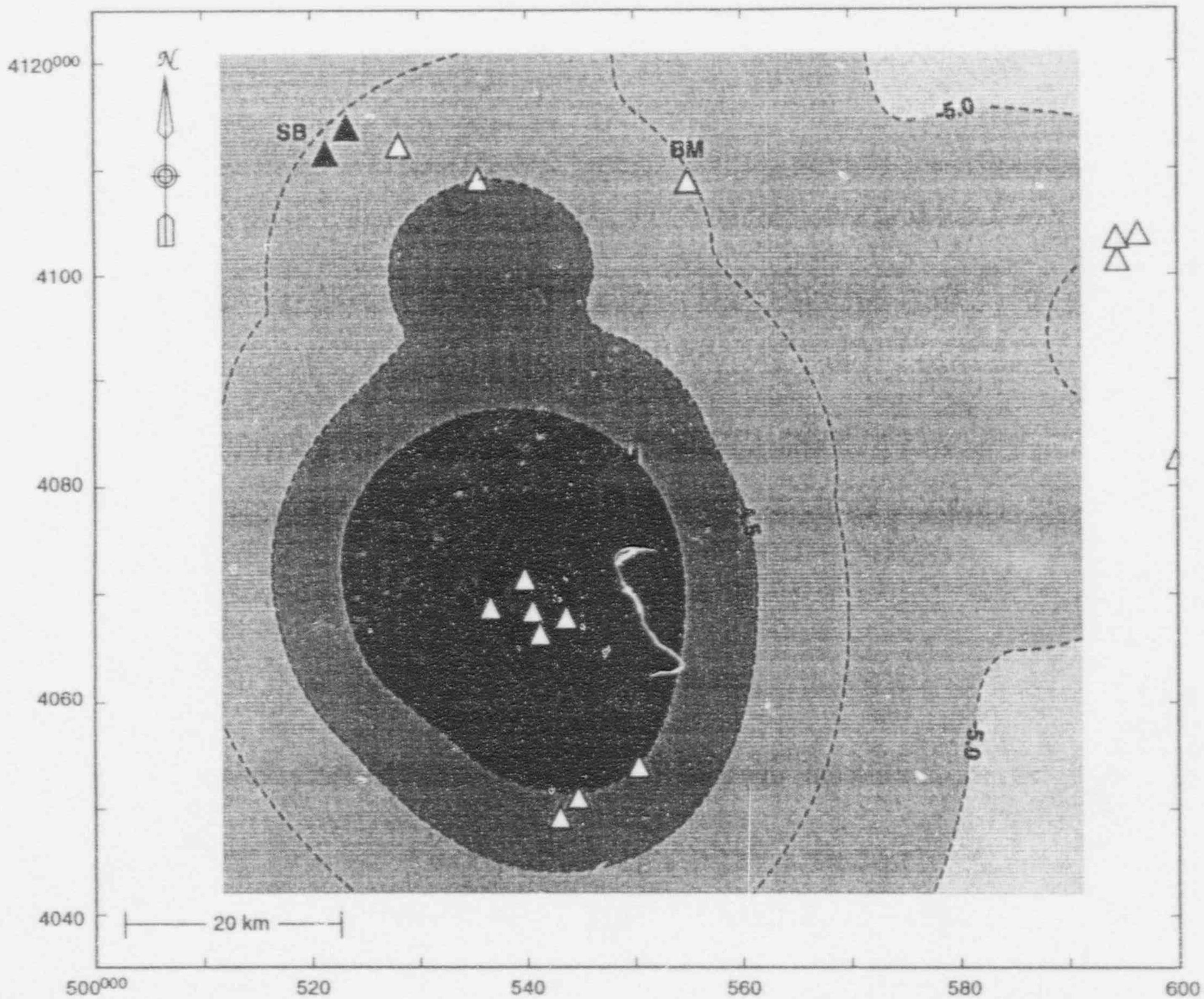
Probability of Disruption x 10^4
youngest ages
mean ages
oldest ages
Range of late Quaternary recurrence rates
0
1
2
3
4
5
6
7
8
9
10
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14
Number Near Neighbor Volcanoes

ACNW294\22



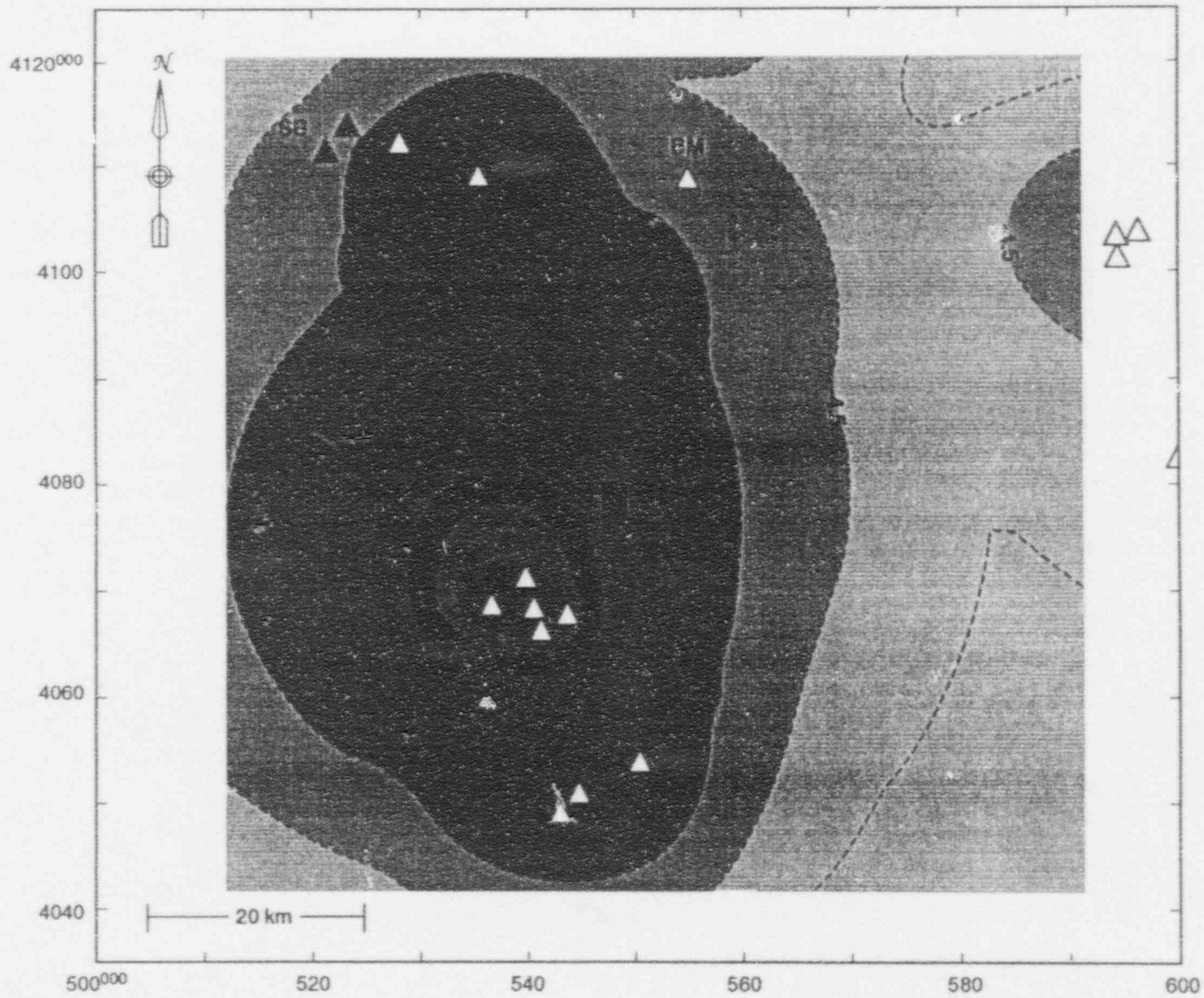
Probability of disruption x 10^4
Number Near Neighbor Volcanoes
a = 10 km²
a = 8 km²
a = 7 km²
a = 6 km²
Range of late Quaternary recurrence rate
0 1 2 3 4 5 6 7 8
1 2 3 4 5 6 7 8 9 10 11 12 13 14

ACNW294\23



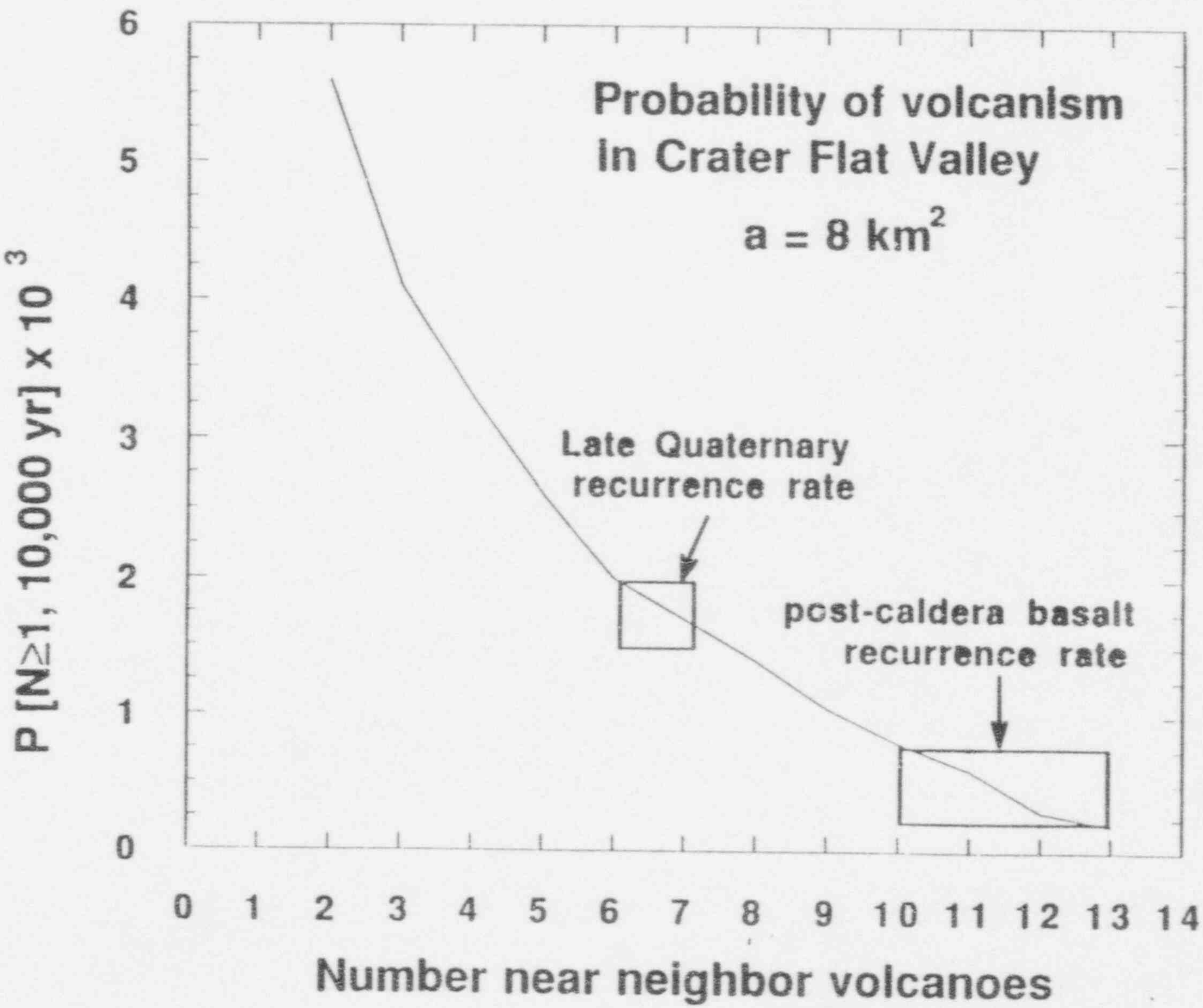
N
SB
BM
-5.0
-4.5
-5.0
20 km
4120000
4100
4080
4060
4040
500000
520
540
560
580
600

ACNW294\24



4120000
4100
4080
4060
4040
500000
520
540
560
580
600
20 km
SB
BM
N

ACNW294\25


Probability of volcanism
in Crater Flat Valley
a = 8 km²
Late Quaternary
recurrence rate
post-caldera basalt
recurrence rate
P [N≥1, 10,000 yr] x 10³
Number near neighbor volcanoes
0
1
2
3
4
5
6
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14

ACNW294\26

PROBABILITY MODELS

Probability of disruption in 10,000 yr using near neighbor Nonhomogeneous Poisson Model

late Quaternary YMR recurrence rate (7 ± 3 *v/my*):

8.0×10^{-5} to 3.5×10^{-4}

with most estimates between 1×10^{-4} and 3×10^{-4}

post-caldera basalt YMR recurrence rate (3 v/my):

6.9×10^{-5} to 9.2×10^{-5}

MARKOV MODEL

Used to predict the most probable location of future eruptions assuming volcanoes have the properties of Markov variables

- Location of most recent eruption most influences position of future eruptions
- With time since last eruption the position of future eruptions tends toward a Homogeneous Poisson Model, described by the diffusion equation
- Parameters estimated from positions of past volcanic eruptions in the region

MARKOV MODEL

The conditional probability density function is given by the Fokker-Plank equation:

$$\frac{\partial P}{\partial t} + (\eta P) - \frac{1}{2}\frac{\partial^2}{\partial x^2}\left(\sigma^2 P\right) = 0$$

Where η and σ_2 are time derivatives of mean and variance of volcano position, respectively.

$$a\left(x_o,t,t_o\right) = E\left\{x(t) \mid x\left(t_o\right) = x_o\right\}$$

$$= \int_{-\infty}^{\infty} x(t)P\left(x,t;x_o,t_o\right)dx$$

$$B\left(x_o,t,t_o\right) = E\left\{\left[x(t) - a\left(x_o,t,to\right)\right]^2 \mid x\left(t_o\right) = x_o\right\}$$

$$= \int_{-\infty}^{\infty} (x - a)^2\, P\left(s,t;x_o,t_o\right)dx$$

MARKOV MODEL

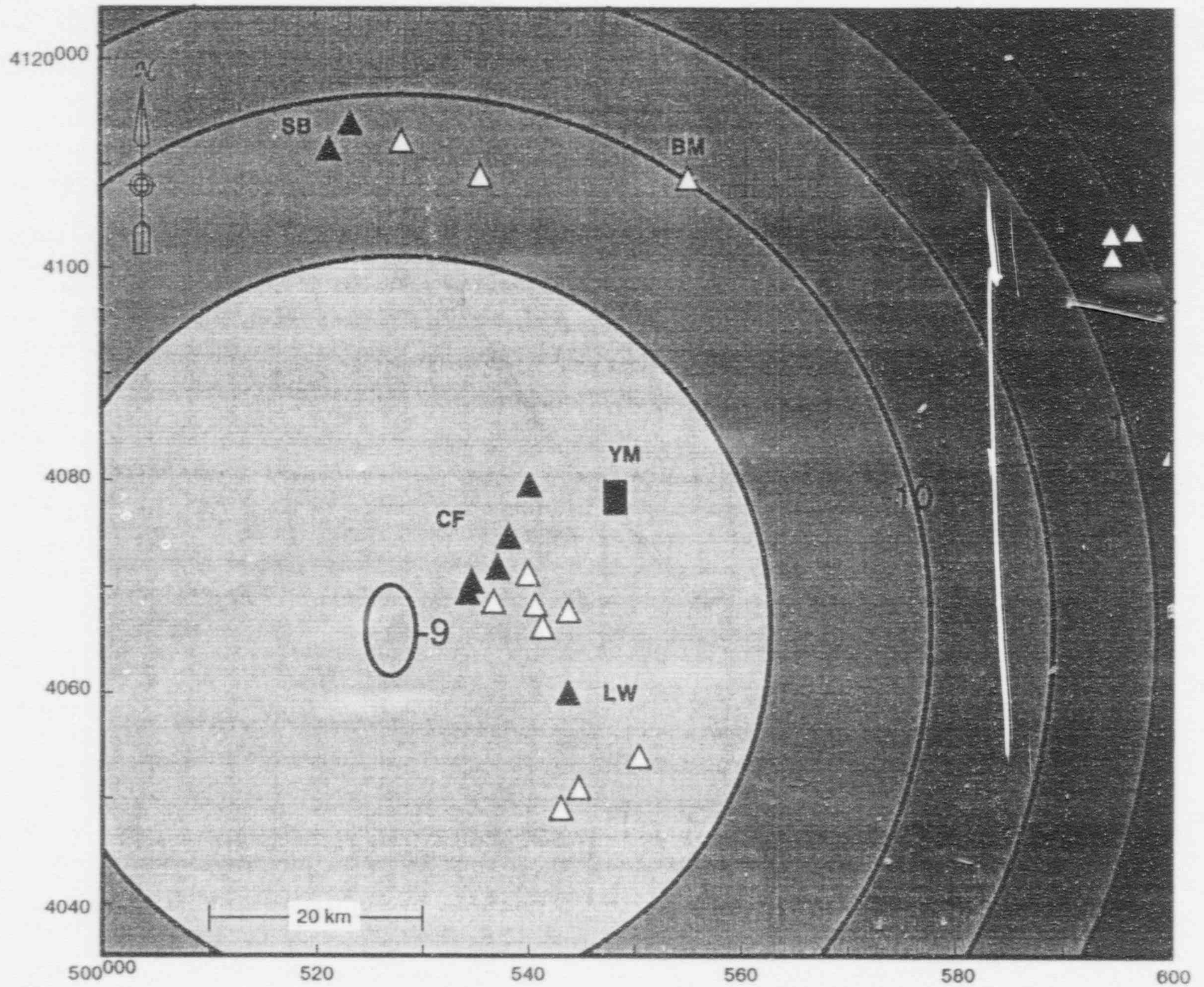
$$\eta(x_o,t_o) = \frac{\partial a(x_o,t,t_o)}{\partial t} \mid t = t_o$$

$$\sigma^2(x_o,t_o) = \frac{\partial b(x_o,t,t_o)}{\partial t} \mid t = t_o$$

In two dimensions the conditional probability density function becomes:

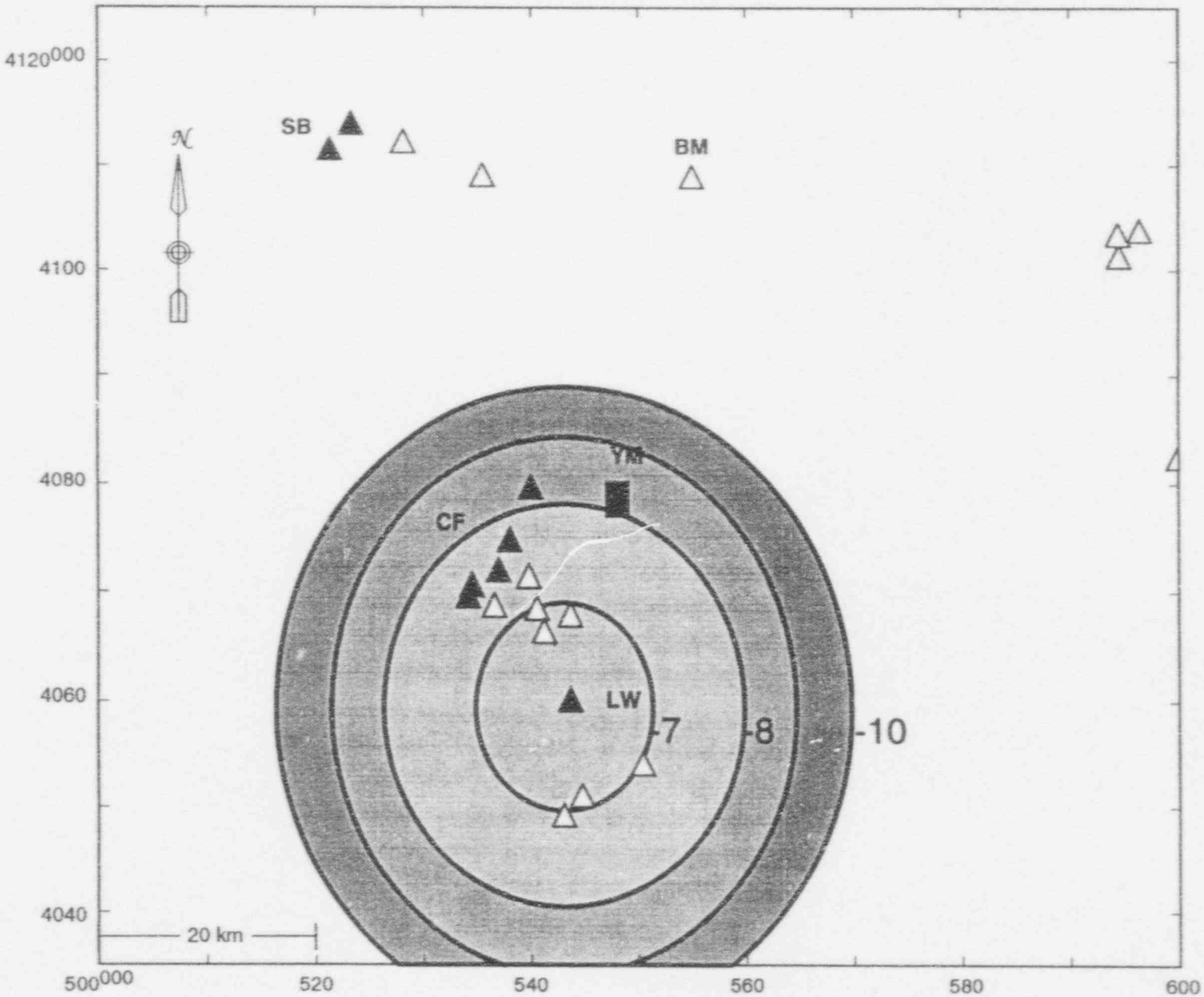
$$P = \frac{1}{2\pi(t - o)\sqrt{\sigma_x^2 \ \sigma_y^2}} \exp\left\{\left(- \frac{[(x(t) - x_o - \eta_x(t - t_o))]^2}{2\sigma_x^2(t - t_o)} - \frac{[(y(t) - y_o - \eta_x(t - t_o))]^2}{2\sigma_y^2(T - t_o)}\right)\right\}$$

with parameters estimated from the volcano distribution.



4120000
4100
4080
4060
4040
500000
520
540
560
580
600
SB
BM
YM
CF
LW
-9
-10
20 km

ACNW294\31


4120000
4100
4080
4060
4040
500000
520
540
560
580
600
SB
BM
YM
CF
LW
-7
-8
-10
20 km
N

ACNW294\32

SUMMARY

- Nonhomogeneous Poisson models indicate probability of direct disruption of between 1×10^{-4} and 3×10^{-4} in 10,000 years. This indicates that volcanism is a potentially adverse condition but is not likely to disqualify the repository on its own. However, mechanisms for focusing magmatism, such as fault control, could change these estimates substantially. Markov models support the idea that future volcanism is most likely to occur in the Crater Flat region.

- Cinder cone eruptions are often explosive and energetic, capable of rapid and wide dispersion of waste. Study of modern eruptions provides the simplest, most defendable, and most efficient means of characterizing the range of eruptive behavior and consequences on repository performance observations of modern volcanism will be rapidly integrated into IPA Phase III.

- Cinder cones cool and degas over long periods of time. Preliminary survey indicate that both forced convection through fracture systems and diffuse degassing are important processes. This heat and mass transfer process would likely directly impact the thermo-hydrologic setting of the repository.

VOLCANIC SYSTEMS OF THE BASIN & RANGE

FIN B-6644

NRC Project Manager: L.A. Kovach

PRESENTED AT THE
ACNW MEETING ON VOLCANISM RESEARCH
FEBRUARY, 1994

Investigators:
Charles B. Connor, Brittain E. Hill
Gerry L. Stirewalt, Stephen R. Young

CNWRA Project Manager: H. Lawrence McKague

ACNW294.1

VOLCANIC SYSTEMS OF THE BASIN & RANGE

VOLCANIC SYSTEMS OF THE BASIN AND RANGE

- Put the Yucca Mountain area into a regional volcanic context
- Develop and test probability models for igneous activity in the Yucca Mountain Region
- Construct models for regional and local tectonic control on igneous activity

FIELD VOLCANISM

- Direct consequences of igneous activity on repository performance
- Indirect consequences of igneous activity on repository performance

VOLCANIC SYSTEMS OF THE BASIN & RANGE

TOPICS FOR DISCUSSION

- Review of dating techniques for Quaternary volcanic rocks
- Regional context for the Yucca Mountain basaltic volcanic system
- Development of a Volcanism Geographic Information System (GIS)

VOLCANIC SYSTEMS OF THE BASIN & RANGE

REVIEW & ANALYSIS OF DATING TECHNIQUES FOR NEOGENE AND QUATERNARY VOLCANIC ROCKS (CNWRA 93-018; Hill, Leslie, and Connor)

- Age uncertainties for volcanoes < 2 m.y. old are relatively large and can affect the results of probability calculations

- Conventional techniques are suitable for dating volcanoes older than about 2 m.y., but many of these older volcanoes are incompletely characterized

- Conventional dating methods are unsuitable for Lathrop Wells

- Developmental dating techniques give an age of 100,000 ± 50,000 years for Lathrop Wells

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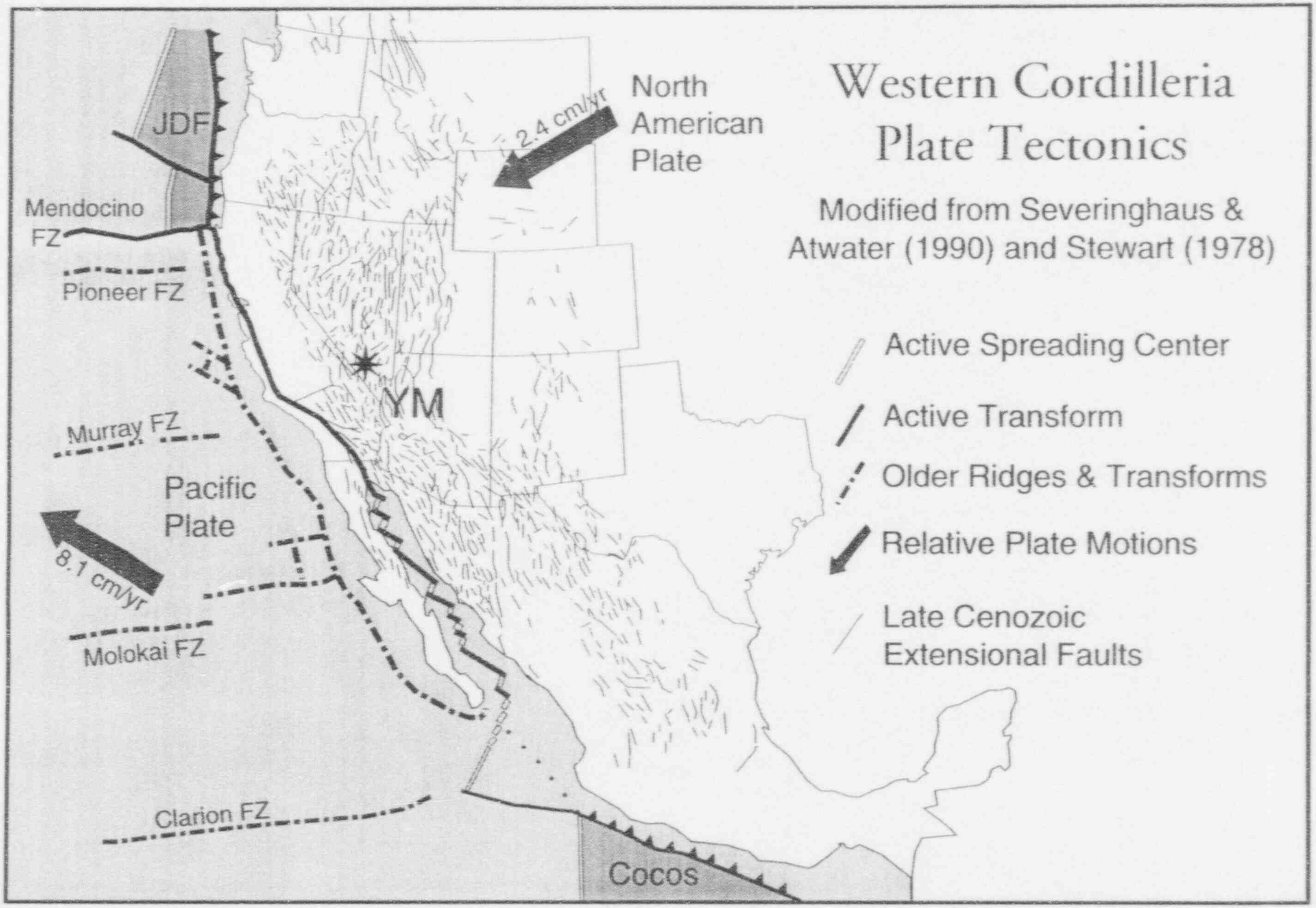
Volcanic Systems of the Basin & Range



VOLCANIC SYSTEMS OF THE BASIN & RANGE

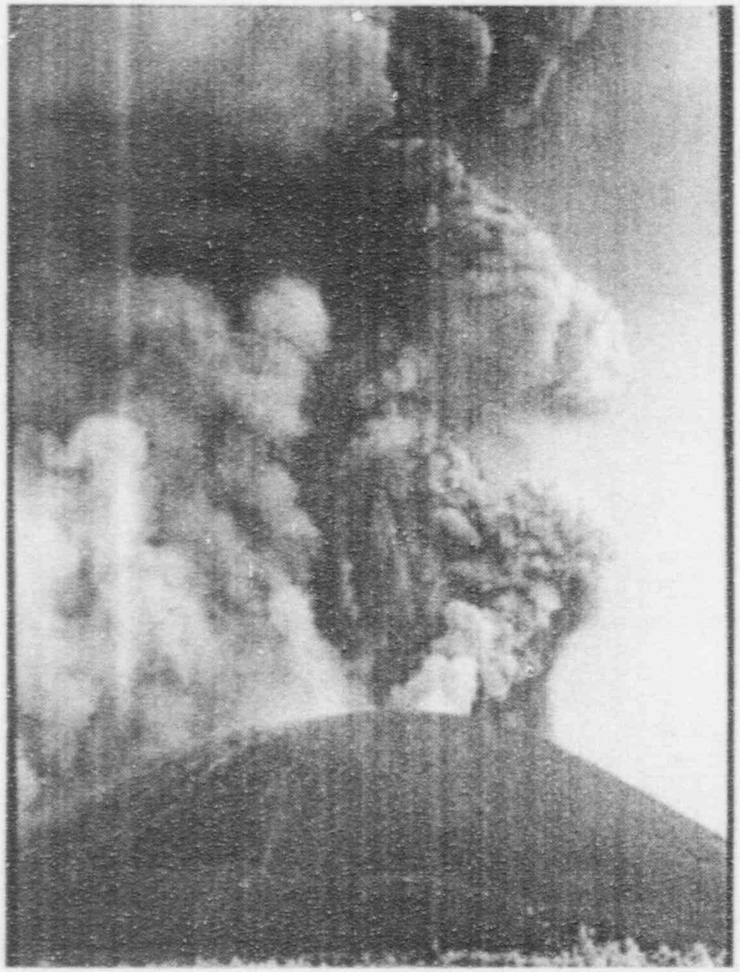
THE PROBABILITIES AND POTENTIAL CONSEQUENCES OF FUTURE IGNEOUS ACTIVITY CANNOT BE FULLY DETERMINED BY ONLY STUDYING PAST ACTIVITY IN THE YUCCA MOUNTAIN REGION (YMR)

- Not all features of igneous activity in the YMR are accessible
- The YMR volcanoes probably do not represent the range of igneous activity possible in the future

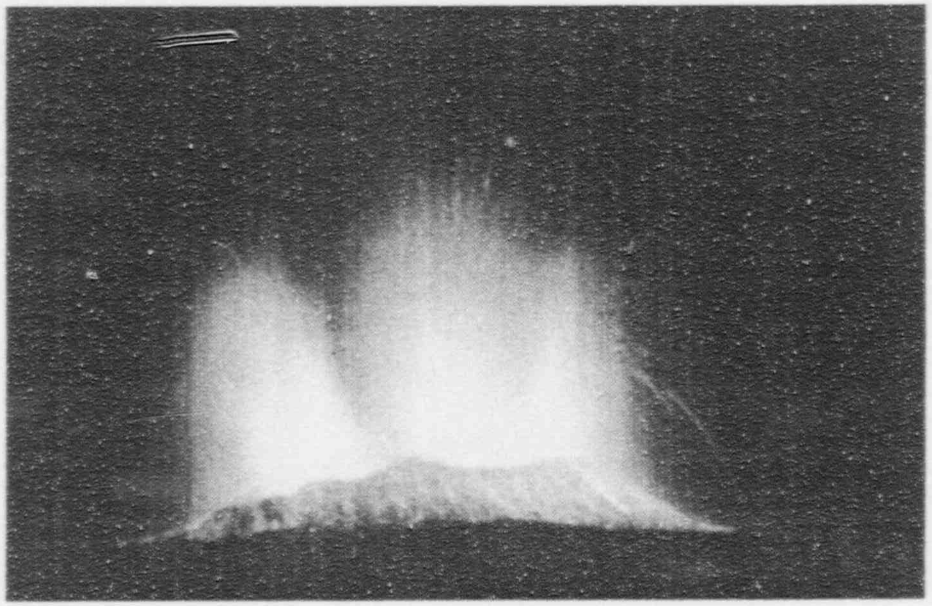
PROBABILITIES AND POTENTIAL CONSEQUENCES CAN BE MORE ACCURATELY DETERMINED BY ADDITIONAL STUDIES AT ANALOGOUS IGNEOUS CENTERS

- Historically active volcanoes
- Appropriate Basin & Range systems

VOLCANIC SYSTEMS OF THE BASIN & RANGE



Tolbachik, Cone I, July 11, 1975

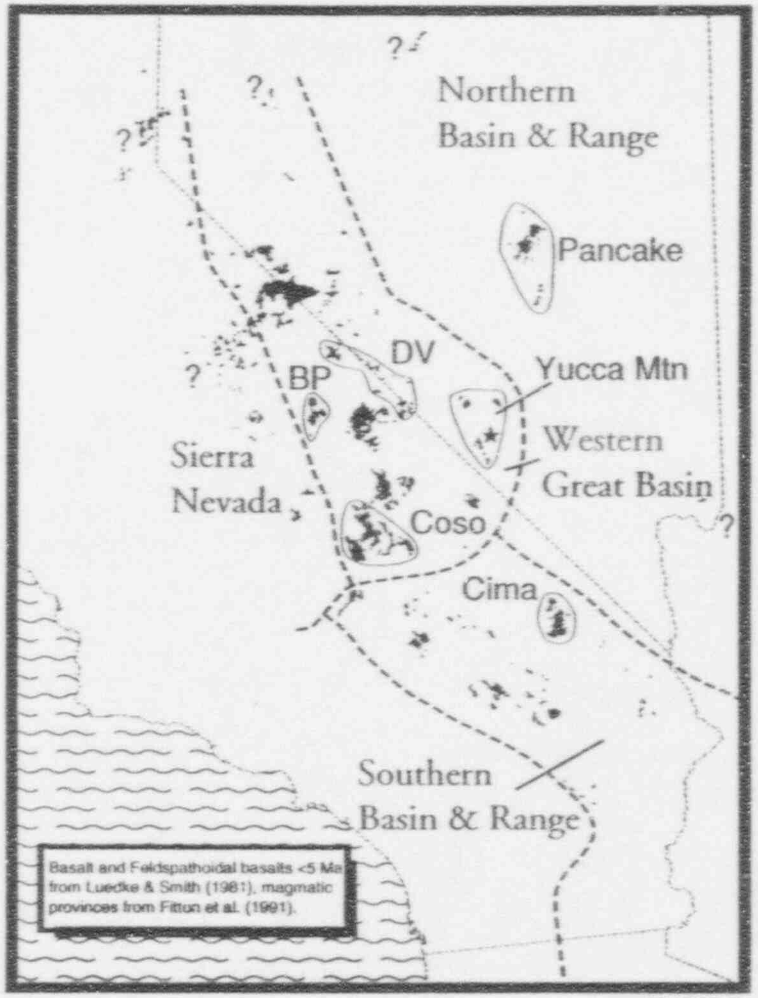


Tolbachik, early Cone IV, August, 1975

TOLBACH.AI

VOLCANIC SYSTEMS OF THE BASIN & RANGE

MANTLE COMPOSITION IS IMPORTANT IN THE BASIN & RANGE



BMAPISO.AI

- Basaltic volcanoes younger than 5 Ma may originate from distinct mantle provinces
- Mantle composition affects magma volatile content and flux in the volcanic system
- Volatile content controls eruption explosivity
- Yucca Mountain Region basalt originates in enriched mantle, higher water contents
- Pancake or Cima originate in primitive mantle, not as analogous to the YMR
- Big Pine (BP) and Death Valley (DV) originate in the same type of enriched mantle as YMR

VOLCANIC SYSTEMS OF THE BASIN & RANGE

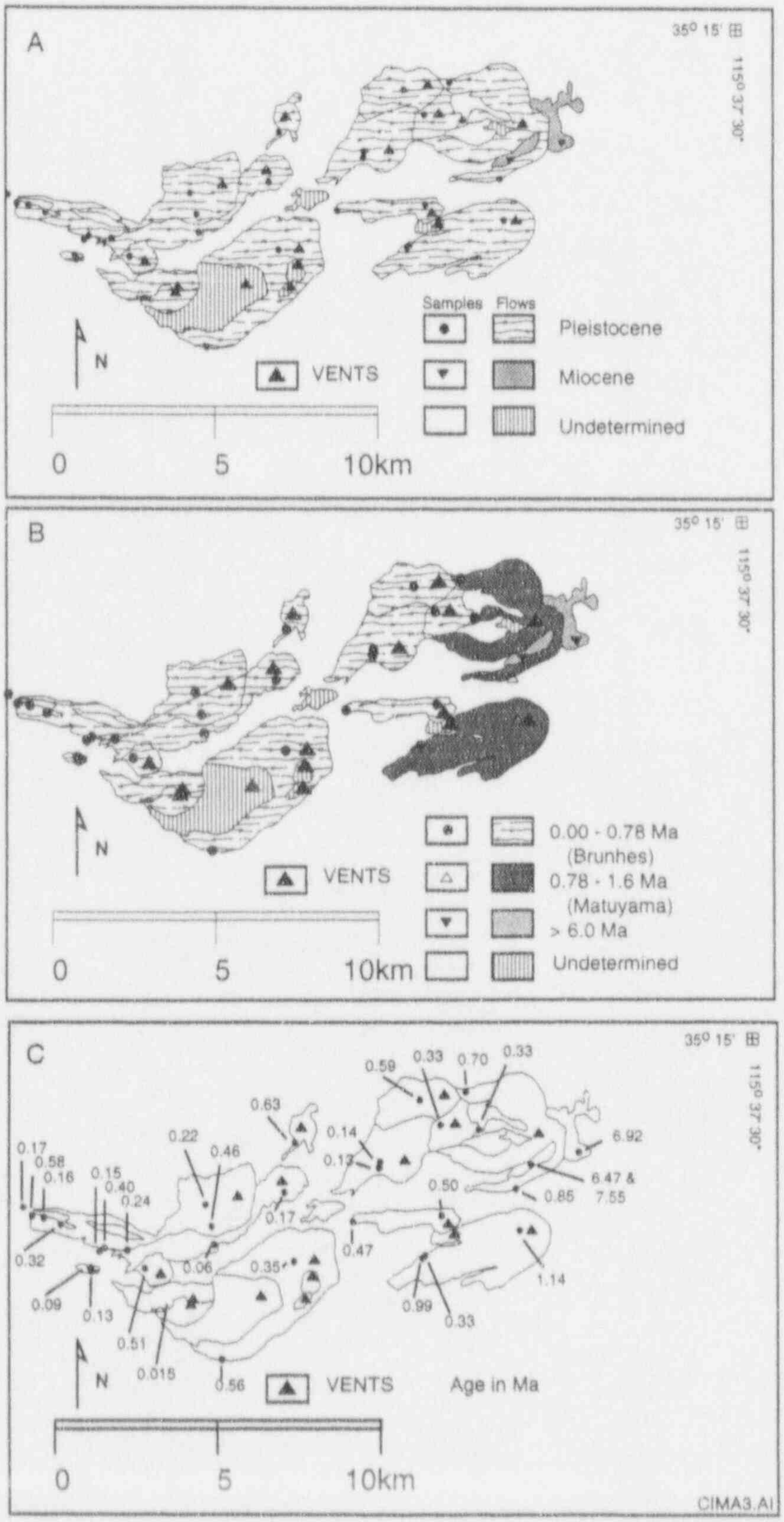
DATA FOR VOLCANIC SYSTEMS OF THE WESTERN BASIN & RANGE

- A variety of data are available for volcanic systems <5 Ma
- Tabular and spatial data are required to construct and test probability and consequence models

NEED TO CONSTRUCT A GEOGRAPHIC INFORMATION SYSTEM (GIS) TO LINK SPATIAL AND TABULAR DATA

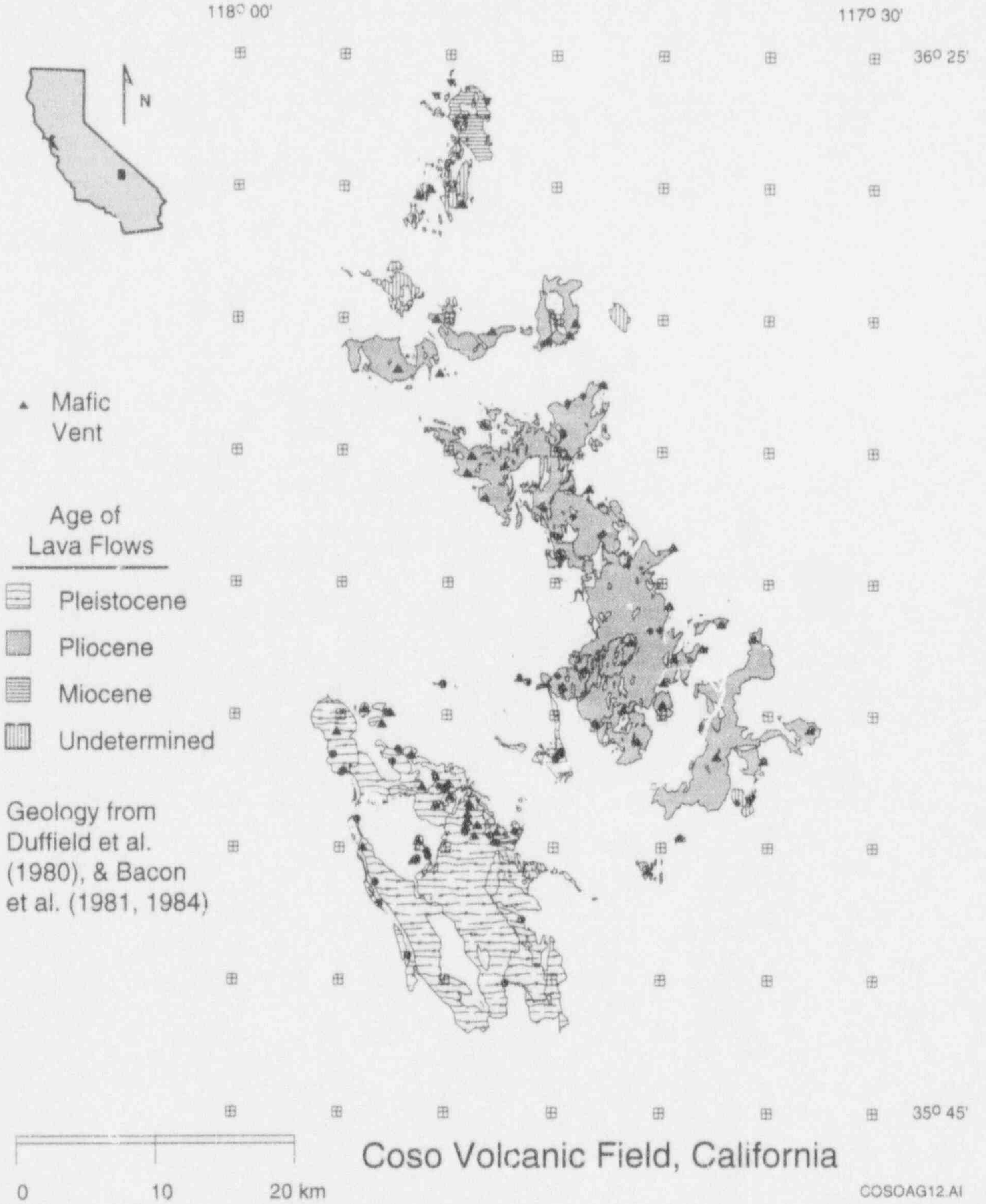
- Evaluate the completeness and accuracy of the DOE license application and research
- Quickly access large amounts of data in a variety of formats
- Develop & test conceptual, empirical, and numerical models of igneous activity that utilize both spatial and tabular data

VOLCANIC SYSTEMS OF THE BASIN AND RANGE



Age relationships for part of the Cima Volcanic Field, CA

VOLCANIC SYSTEMS OF THE BASIN & RANGE



Coso Volcanic Field, California

COSOAG12.AI

VOLCANIC SYSTEMS OF THE BASIN & RANGE

EXAMPLE OF A TESTABLE VOLCANISM GIS MODEL:

- HYPOTHESIS: Volcanoes are restricted to low-elevation alluvial basins. Yucca Mountain is not a low-elevation alluvial basin and thus has a decreased risk of future volcanic activity.

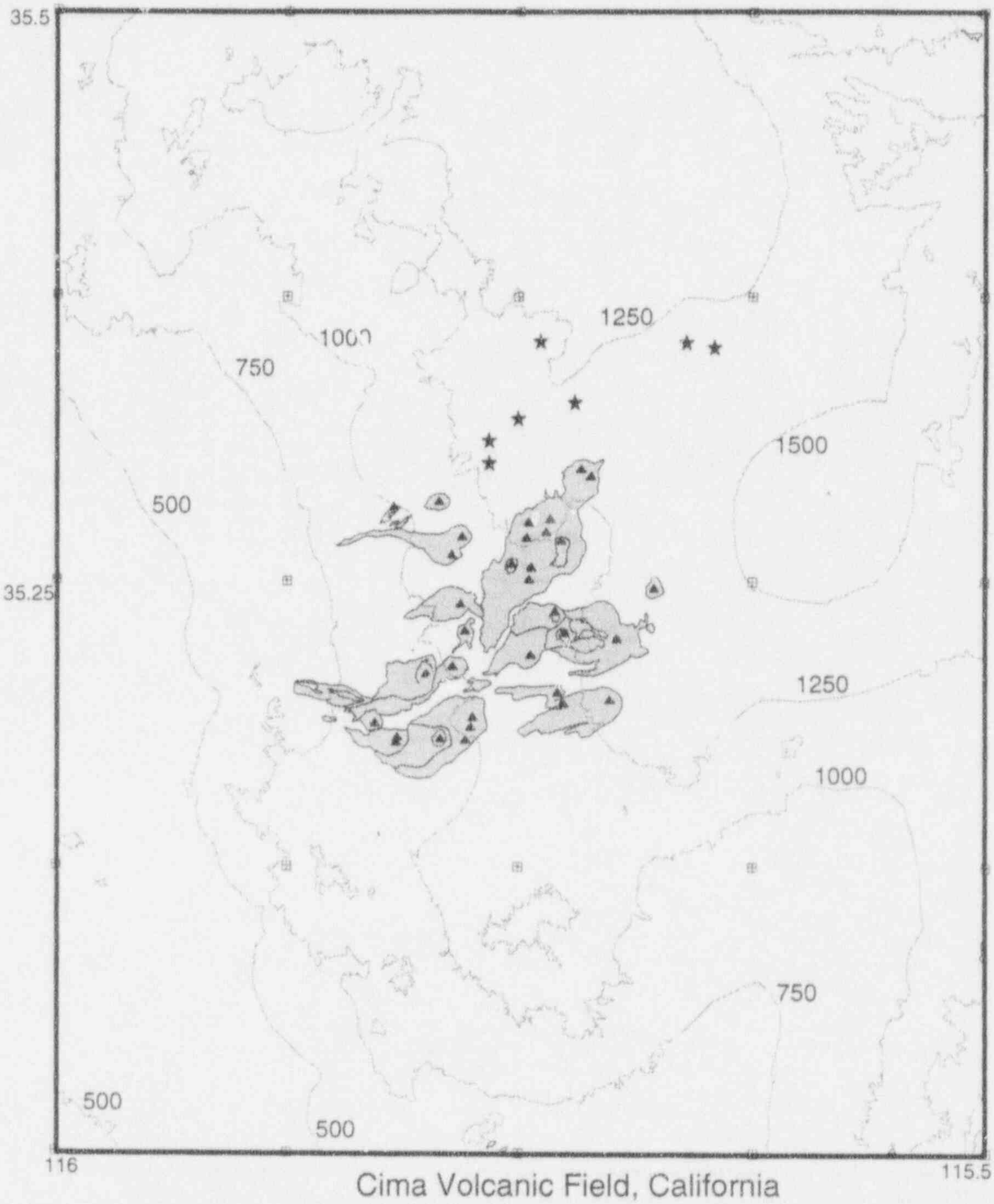
- BASIS: Crowe et al. (1993, *Preliminary Draft: Status of Volcanic Hazard Studies for the Yucca Mountain Site Characterization Project*) "..there is a common but not universal restriction of sites of Quaternary basaltic volcanic centers to alluvial basins of the basin-range province [p. 138]...Because the Yucca Mountain site is located in a range interior, a random model will overestimate the disruption probability [p. 283]."

- TEST: Are volcanoes restricted to alluvial basins or low elevations?

- YMR OBSERVATIONS:
    - Crest of Yucca Mountain to lowest Quaternary volcano (Lathrop Wells) is 670 m
    - Quaternary YMR volcanoes distributed over 700 m of vertical relief

- OBSERVATIONS AT OTHER ANALOGOUS VOLCANIC SYSTEMS

VOLCANIC SYSTEMS OF THE BASIN & RANGE



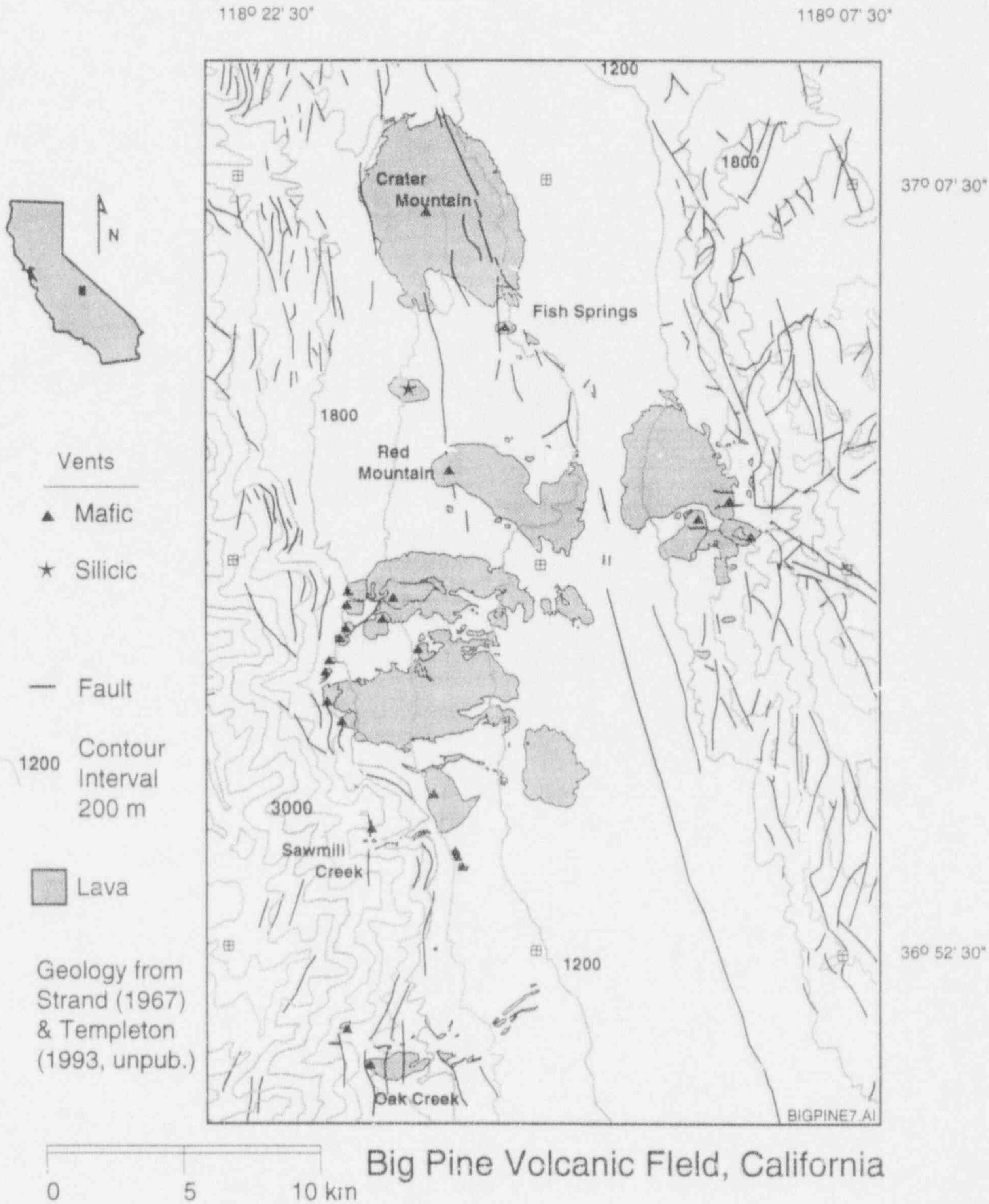
Cimа Volcanic Field, California

Contour Interval = 250 m, topography from Ivanpah, CA-NV 1:100,000 base

Geology from Dohrenwend et al. (1984) VENTS: ▲ Quaternary ★ Neogene

CIMACNT2.AI

VOLCANIC SYSTEMS OF THE BASIN & RANGE



Big Pine Volcanic Field, California

VOLCANIC SYSTEMS OF THE BASIN & RANGE

CONCLUSIONS

- Uncertainty in Yucca Mountain Region Quaternary volcano ages affects probability models
- Lathrop Wells volcano is likely 100 ± 50 ka
- Not all Basin and Range volcanic fields are directly analogous to the Yucca Mountain Region
- Spatial and tabular data must be utilized in a GIS to construct and test volcanism models
- Yucca Mountain apparently does not represent a robust topographic barrier to basaltic volcanism

United States
Nuclear Regulatory Commission

BRIEFING ON DRAFT POLICY STATEMENT FOR AGREEMENT STATE ADEQUACY AND COMPATIBILITY

Sheldon A. Schwartz, Deputy Director
Office of State Programs

FEBRUARY 23, 1994

United States
Nuclear Regulatory Commission

OUTLINE

- ✓ BACKGROUND
- ✓ PRINCIPLES OF THE AGREEMENT STATE PROGRAM
- ✓ RESULTS OF DISCUSSIONS WITH VARIOUS GROUPS
- ✓ RELATIONSHIP OF DRAFT COMPATIBILITY POLICY AND LOW-LEVEL WASTE REQUIREMENTS
- ✓ FUTURE ACTIONS

BACKGROUND

- ✓ Past Agreement State Compatibility Concerns
- ✓ Commission Directed Policy Development
- ✓ Establishment of Compatibility Working Group
- ✓ May 20, 1993 Public Meeting
- ✓ July 26-27, 1993 Public Workshop
- ✓ August 30, 1993 Commission Briefing
- ✓ October 24-27, 1993 All Agreement States Meeting
- ✓ January 24, 1994 Commission Briefing

United States
Nuclear Regulatory Commission

PRINCIPLES OF THE AGREEMENT STATE PROGRAM

- ✓ *Recognize the Interests of States*
- ✓ *Recognize the need for cooperation between the Commission and the States*
- ✓ *Promote an orderly regulatory pattern between the Commission and the States*
- ✓ *Provide for coordination of the development of radiation standards and other policies*
- ✓ *Two separate Requirements -- Adequacy and Compatibility*

RESULTS OF DISCUSSIONS WITH VARIOUS GROUPS

✓ *States*

- *Minimum number of requirements for compatibility*
- *Uniformity for interstate commerce*
- *Uniformity of radiation standards*
- *Early and substantive involvement*

✓ *Regulated Community*

- *Strict adherence to uniform national radiation standards*

✓ *Environmental Community*

- *Flexibility to adopt more stringent requirements*

RELATIONSHIP BETWEEN ADEQUACY AND COMPATIBILITY

- ✓ *Adequacy component provides for an acceptable level of protection for public health and safety in an Agreement State.*

- ✓ *Compatibility component provides for the overall national interest in radiation protection.*

ADEQUACY COMPONENT

- ✓ Requires that the level of protection of public health and safety be equivalent to, or greater than, that provided by the NRC.
- ✓ Would not require that NRC requirements be implemented essentially verbatim or through a particular mechanism such as a regulation, unless one of the compatibility criteria for identical adoption needed to be met
- ✓ More stringent requirements do not preclude or effectively preclude a practice
- ✓ More stringent dose limits are only applicable to one class of licensee

ADEQUATE MEANS:

An acceptable level of protection of the public health and safety from the radiation hazards associated with the use of byproduct, source, and special nuclear materials.

AN ADEQUATE AGREEMENT STATE PROGRAM MEANS:

An effectively implemented regulatory program containing elements, regulations, policies, and procedures considered necessary by the Commission to provide an acceptable level of protection for the public health and safety from the radiation hazards associated with the use of byproduct, source, and special nuclear materials.

EXAMPLE ELEMENTS OF AN ADEQUATE PROGRAM

- Protection
- Regulations
- Inspection Program
- Enforcement Program
- Staffing and Personnel Qualifications
- Statutes
- Laboratory Support
- Licensing Program
- Investigations (Response to Events)

COMPATIBILITY COMPONENT

- ✓ *Focuses on State action or inaction that would have extraterritorial impacts either on other States or on the effectiveness of the national program.*
- ✓ *Requires the essentially identical adoption of certain elements of NRC regulatory program*

COMPATIBLE MEANS:

The consistency between NRC and Agreement State regulatory programs which is needed in order to establish a national radiation protection program for the regulation of byproduct, source and special nuclear material which assures an orderly and effective regulatory pattern in the administration of this national program. Compatibility shall be aimed at ensuring that the flow of interstate commerce is not impeded, that effective communication in the radiation protection field is maintained, that central radiation protection concepts applicable to all licensees are maintained, and that information needed for the study of trends in radiation protection and other national program needs are ascertained.

A COMPATIBLE AGREEMENT STATE PROGRAM MEANS:

A regulatory program containing elements, regulations, policies, and procedures considered necessary by the Commission to effectively implement the term "compatible" as defined above.

CRITERIA FOR IDENTICAL REQUIREMENTS

- ✓ Avoid a significant burden on interstate commerce
- ✓ Ensure clear communication on fundamental radiation protection terminology
- ✓ Ensure the establishment of common dose limits applicable to all licensees in 10 CFR 20
- ✓ Assist the NRC in evaluating the effectiveness of the overall national program for radiation protection

EXAMPLE ELEMENTS OF A COMPATIBLE PROGRAM

- Radiation Labels, Signs, and Symbols
- Uniform Manifest
- Transportation Regulations
- Event Reporting
- Reciprocity
- Records and Reports
- Radiation Protection Terminology
- Radiation Protection Standards

RELATIONSHIP OF DRAFT COMPATIBILITY POLICY AND LOW-LEVEL WASTE REQUIREMENTS

- ✓ The staff believes that the draft policy is consistent with previous actions regarding compatibility or Agreement State LLW programs
- ✓ The draft policy should apply to the LLW compatibility determiniations

FUTURE ACTIONS

- ✓ *Publish draft policy statement in Federal Register for 90 days*
- ✓ *Conduct a public meeting*
- ✓ *Prepare a Commission Paper transmitting the final proposed Policy Statement*

PRESENTATION TO THE ADVISORY COMMITTEE ON NUCLEAR WASTE

UNITED STATES NUCLEAR REGULATORY COMMISSION

DIVISION OF HIGH-LEVEL WASTE MANAGEMENT

TOPICAL REPORT REVIEW PLAN

DIVISION OF HIGH-LEVEL WASTE MANAGEMENT

TOPICAL REPORT REVIEW PLAN

PRESENTATION TO THE

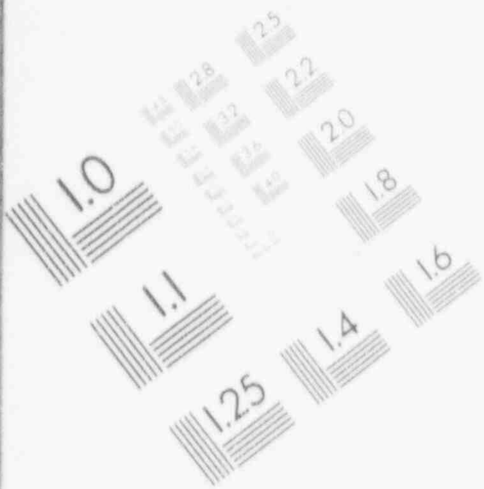
ADVISORY COMMITTEE ON NUCLEAR WASTE

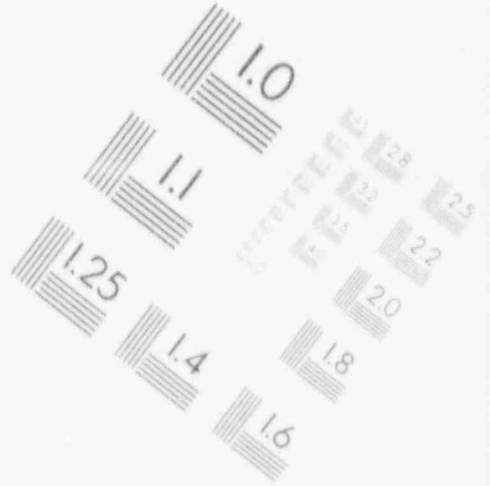
February 23, 1994

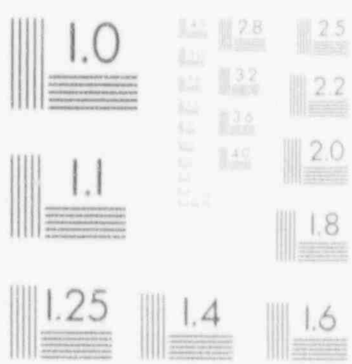
Charlotte E. Abrams
Senior Project Manager
Tel. No.:(301) 504-3403

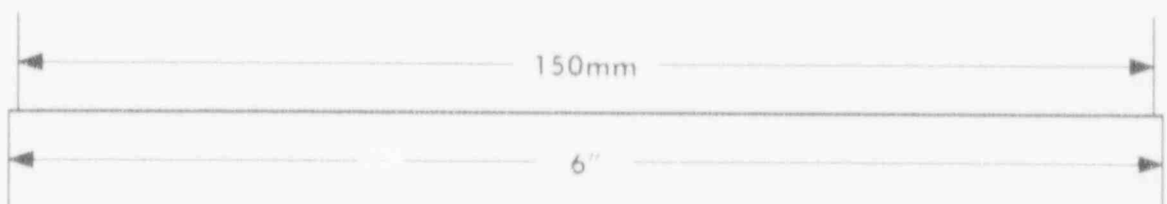
2

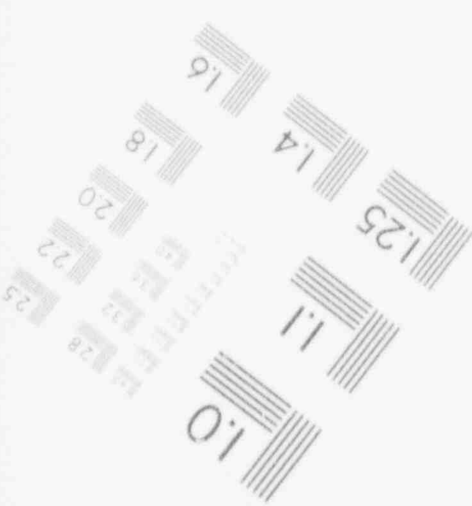
IMAGE EVALUATION TEST TARGET (MT-3)

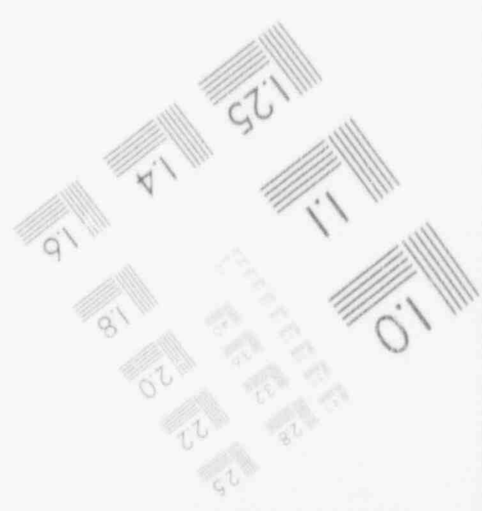












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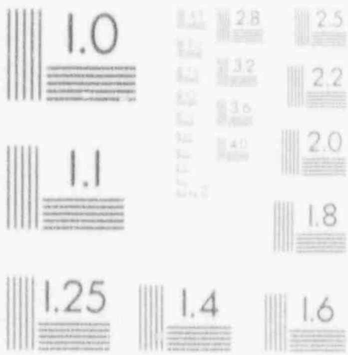

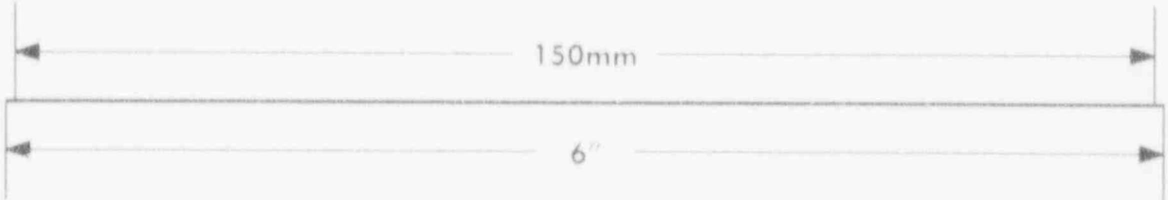

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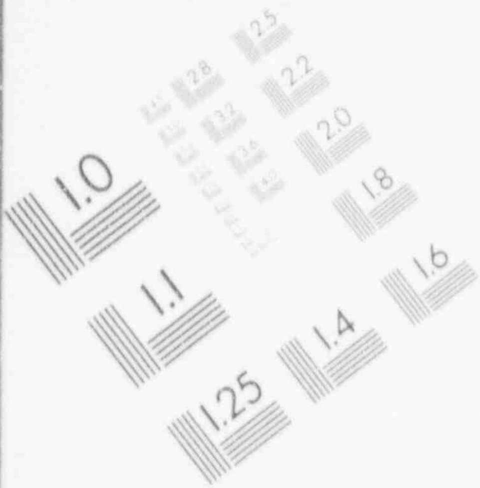

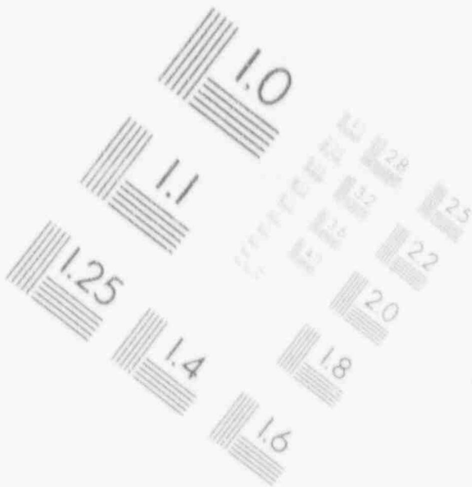

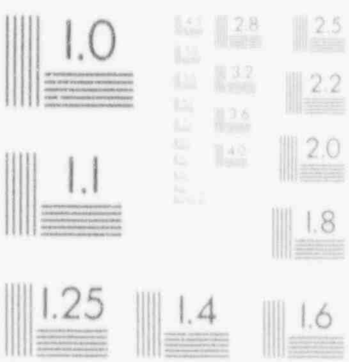

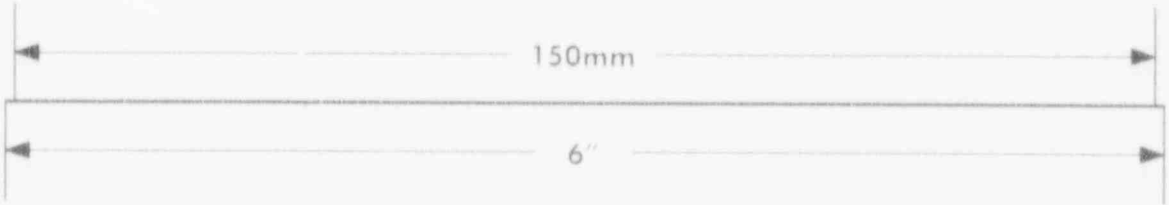

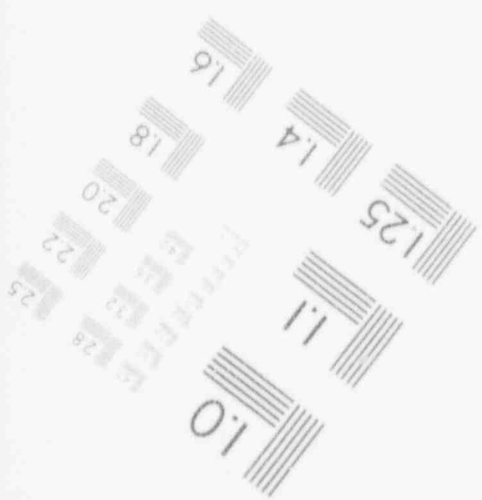

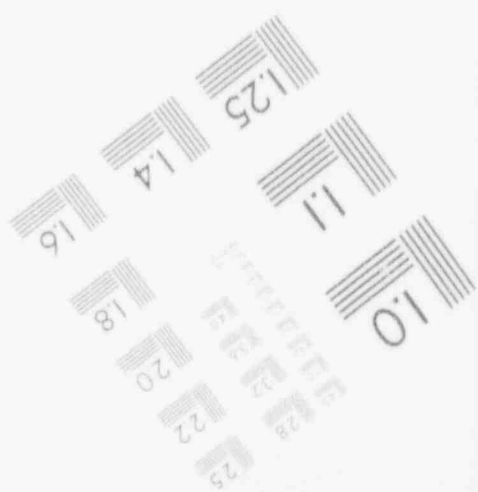

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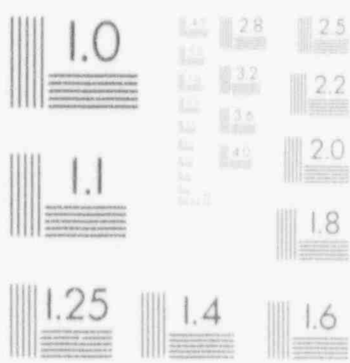

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HISTORY: NRC TOPICAL REPORT PROGRAM

PROCEDURE WHEREBY INDUSTRIAL ORGANIZATION MAY SUBMIT REPORT ON SPECIFIC IMPORTANT-TO-SAFETY SUBJECTS TO BE REVIEWED INDEPENDENTLY OF A CONSTRUCTION PERMIT OR OPERATING LICENSE.

BENEFIT: MINIMIZATION OF TIME AND EFFORT THAT APPLICANT AND NRC SPEND ON SUBJECTS REPEATED IN NUMEROUS LICENSING ACTIONS.

NRC TOPICAL REPORT PROGRAM (continued)

CRITERIA:

- DEALS WITH SUBJECT WHICH CAN BE REVIEWED INDEPENDENTLY OF ANY SPECIFIC LICENSE APPLICATION (e.g., design, analytical models or techniques, or performance testing of components or systems);

- CAN BE REFERENCED IN MULTIPLE LICENSE APPLICATIONS;

NRC TOPICAL REPORT PROGRAM (continued)

- CONTAINS COMPLETE AND DETAILED INFORMATION ON SUBJECT PRESENTED; AND

- COMPLETION OF REPORT WILL INCREASE EFFICIENCY OF APPLICATION REVIEW.

HIGH-LEVEL WASTE MANAGEMENT TOPICAL

REPORTS

- FOCUS ON:

  DESIGNS, METHODOLOGIES, TESTS, TECHNIQUES, OR ANALYTICAL MODELS UNDER EVALUATION DURING PRE-LICENSING

  APPLICATION TO A PARTICULAR TECHNICAL ISSUE AT A SPECIFIC SITE

- CONSIST OF PORTION OF INFORMATION REQUIRED BY APPLICANT UNDER 10 CFR PART 60

HIGH-LEVEL WASTE MANAGEMENT

TOPICAL REPORTS (continued)

- MAY BE INCORPORATED BY REFERENCE IN THE LICENSE APPLICATION (LA), IF ACCEPTED BY THE NRC STAFF

- EXPECTED TO BE REFERENCED IN DOE'S LA ANNOTATED OUTLINE (AO); WILL SERVE AS THE BASIS FOR PREPARATION OF PORTIONS OF THE AO

NRC STAFF ACCEPTANCE:

- SUBJECT ADDRESSED TO DEGREE THAT STAFF HAS NO QUESTIONS OR DISAGREEMENTS AT TIME OF REVIEW

- MATTERS PRESENTED IN TOPICAL REPORT ARE RESOLVED AT THE NRC STAFF LEVEL, UNLESS NEW INFORMATION BECOMES AVAILABLE THAT COULD INVALIDATE CONCLUSIONS.

- TOPICAL REPORTS WILL NOT SERVE AS PIECEMEAL DETERMINATION THAT LA COMPLIES WITH NRC REQUIREMENTS.

- RESOLUTION OF ISSUES STILL NEED TO BE EVALUATED IN CONTEXT OF OVERALL SYSTEM.

TOPICAL REPORT REVIEW PLAN

PURPOSE

PROCEDURE FOR SUBMITTAL

CONTENTS

EVALUATION PROCESS

PURPOSE OF REVIEW

TO PROVIDE GUIDANCE TO DOE ON CONCERNS RELATED TO INFORMATION SUBMITTED

TO DETERMINE IF THE TOPICAL REPORT IS ACCEPTABLE FOR REFERENCING IN THE LA, INCLUDING WHETHER DOE HAS DEMONSTRATED AN ACCEPTABLE METHOD TO MEET REGULATORY REQUIREMENTS.

CRITERIA FOR TOPICAL REPORT ACCEPTANCE

- DEALS WITH SPECIFIC IMPORTANT-TO-SAFETY OR IMPORTANT-TO-WASTE-ISOLATION SUBJECT.
- DEALS WITH SUBJECT UNDER EVALUATION DURING PRE-LICENSING PHASE AND CAN BE REFERENCED IN THE LA.
- CONTAINS COMPLETE AND DETAILED INFORMATION ON SUBJECT PRESENTED.
- ACCEPTANCE WILL RESULT IN INCREASED EFFICIENCY OF STAFF'S LA REVIEW.

PROCEDURE FOR SUBMITTAL

- SUBMITTAL OF ANNOTATED OUTLINE FOR TOPICAL REPORT
- NRC DETERMINATION THAT SUBJECT QUALIFIES FOR A TOPICAL REPORT
- SUBMITTAL OF REPORT
- NRC ACCEPTANCE REVIEW
- NRC REVIEW OF TOPICAL REPORT

CONTENTS OF REPORT

ABSTRACT SUMMARIZING CONTENTS AND CONCLUSIONS OF REPORT

INTRODUCTION, STATING PURPOSE AND DEFINING SCOPE OF REPORT

BODY, ORGANIZED ACCORDING TO THE DISCRETION OF DOE

REFERENCES

APPENDICES

EVALUATION PROCESS

- EVALUATION AGAINST CRITERIA
- TECHNICAL REVIEW, RESULTING IN QUESTIONS TO DOE, IF NECESSARY
- DOE ADDRESSES QUESTIONS
- STAFF PREPARES DRAFT SAFETY EVALUATION (SE)
- INTERACTION INVOLVING ALL PARTIES
- CONSIDERATION OF COMMENTS FROM ALL PARTIES
- FINAL SE

IF A TOPICAL REPORT IS FOUND TO BE ACCEPTABLE FOR REFERENCING IN THE LA, THE STAFF WILL NOTIFY DOE OF THE EXTENT OF AND CONDITIONS FOR ACCEPTANCE IN ITS SE.

A preprint from the

Center for Nuclear Waste Regulatory Analyses

Estimating the Probability of Volcanic Distruption of the Candidate Yucca Mountain Repository Using Spatially and Temporally Nonhomogeneous Poisson Models

Charles B. Connor and Brittain E. Hill
Center for Nuclear Waste Regulatory Analyses
Southwest Research Institute
6220 Culebra Road
San Antonio, TX 78228-0510

American Nuclear Society Focus '93 Meeting
Las Vegas, Nevada
September, 1993

ESTIMATING THE PROBABILITY OF VOLCANIC DISRUPTION OF THE CANDIDATE YUCCA MOUNTAIN REPOSITORY USING SPATIALLY AND TEMPORALLY NONHOMOGENEOUS POISSON MODELS

Charles B. Connor and Brittain E. Hill
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ABSTRACT

The candidate high-level nuclear waste repository site at Yucca Mountain, Nevada, is located near Quaternary basaltic volcanoes. The probability of volcanic disruption of the candidate repository site during the next 10,000 years must be determined to evaluate the risks associated with basaltic volcanism. Our estimate of Quaternary recurrence rates in the Yucca Mountain region is 7±3 volcanoes per million years (v/my), which reflects the uncertainties present in the ages of Quaternary cinder cones. Application of Clark-Evans and Hopkins F-tests indicates that the locations of Quaternary and Neogene basaltic volcanoes near the proposed repository site are not adequately described by a homogeneous Poisson distribution because mafic volcanoes in the Yucca Mountain area cluster. Nonhomogeneous Poisson models using six to seven near-neighbor volcanoes result in regional recurrence rates that are within the range of calculated Quaternary recurrence rates. Probabilities for disruption of a repository area calculated using a range of Quaternary recurrence rates vary from 8.0×10^{-5} to 3.4×10^{-4} for a 10,000 year period, with most estimates between 1×10^{-4} and 3×10^{-4}. Spatially nonhomogeneous Poisson models using ten to eleven near neighbors produce recurrence rates comparable to average rates of basaltic volcanism since the cessation of Miocene silicic volcanism (≈3 v/my) and disruption probabilities of 6.9×10^{-5} to 9.2×10^{-5}.

INTRODUCTION

Volcanic eruptions at or adjacent to the candidate high-level waste (HLW) repository could potentially result in release of HLW into the accessible environment. Determining the probability of a volcanic eruption in the repository area is thus a critical step in the evaluation of potential risks associated with the Yucca Mountain site. The objective of this paper is to present a range of probability models that take into account some of the temporal and spatial controls on Quaternary mafic volcanoes in the Yucca Mountain region (YMR).

Basaltic volcanism has been a characteristic of the YMR since about 11 Ma.[1] The preserved volcanic units represent the eruption of at least 40 km^3 of generally alkaline basalt, with volumes of individual centers ranging from >10 to <0.1 km^3.[1-2] Basaltic volcanoes in the region represent a variety of eruption styles, and range from relatively low explosivity effusions of lava flows and small-volume cinder cones, to highly explosive phreatomagmatic eruptions.[3] Although each eruptive style will impact the repository differently, any type of mafic eruption within or adjacent to the repository would adversely affect repository performance.[1,4] The focus of this paper is to estimate the probability of mafic volcanic activity within or adjacent to the repository during the next 10,000 years, through the application of nonhomogeneous Poisson models.

Figure 1 illustrates the location of mapped and inferred post-caldera basaltic vents in the YMR.[3] Geographic information and estimated age of initial eruptive activity at each center are summarized in Table 1. Dated basaltic vents vary in age from approximately 10 Ma for the Paiute Mesa basalts to approximately 0.10 Ma for the Lathrop Wells cinder cone.[5-6] Various dating methods have yielded estimated ages for Lathrop Wells of between 0.4 and 0.02 Ma.[7-10] There are relatively few high-precision dates from other cinder cones in the area, so these dates are considered to be estimates.

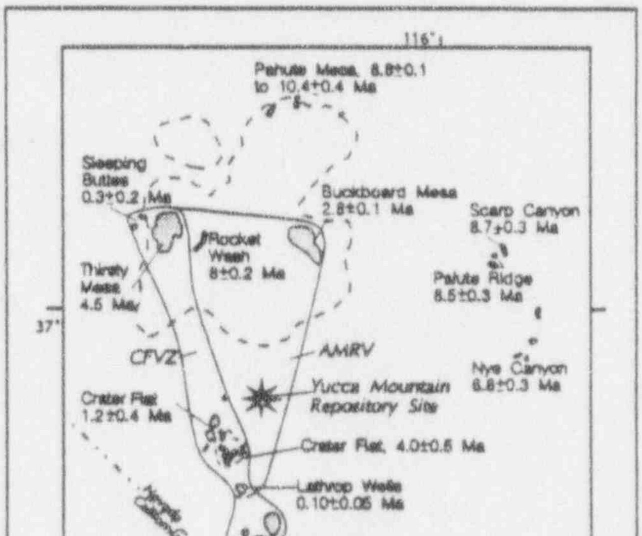

FIGURE 1: Post-caldera basaltic vent locations in the YMR (modified from Crowe[3]). Basaltic units are shaded by relative age and mean numeric age is posted (Table 1). Miocene calderas of the Timber Mountain caldera complex (dashed lines) and HLW repository (star) are shown.

YMR RECURRENCE RATES FOR VOLCANO FORMATION

All probability models proposed to date rely on estimates of the expected regional recurrence rate of volcanism in the YMR in order to calculate the probability of future disruptive volcanic activity. Most previous estimates of regional recurrence rate are between 1 and 12 volcanoes per million years (v/my).[11-15] Ho et al.[13] and Ho[12] provide several examples of techniques used to estimate regional recurrence rates. The simplest approach is to average the number of events that have occurred during some arbitrary time period. For instance, Ho et al.[13] average the number of volcanoes that have formed during the Quaternary (1.6 m.y.) to calculate the recurrence rate. Through this approach they estimate an expected recurrence rate of 5 v/my. Crowe et al.[4] averaged the number of new volcanoes over a 1.8 million year period. Crowe et al.[15] consider the two Little Cones to represent a single magmatic event, and therefore conclude that there are seven Quaternary centers in the region. This lowers the estimated recurrence rate to approximately 4 v/my. The probability of a new volcano forming in the YMR during the next 10,000 yr is between 4% and 5%, assuming a recurrence rate of between 4 and 5 v/my.

An alternative approach to calculating recurrence rate is the repose-time method.[13] In this method, a recurrence rate is defined using a maximum likelihood estimator that averages events over a specific period of volcanic activity:

$$\lambda = \frac{(E-1)}{(T_o - T_y)} \qquad (1)$$

where E is the number of events, T_o is the age of the first event, T_y is the age of the most recent event, and λ is the estimated recurrence rate. Using eight Quaternary volcanoes as the number of events, E, and 0.1 Ma for the formation of Lathrop Wells, the estimated recurrence rate depends on the age of the first Quaternary volcanic eruption in Crater Flat (Figure 1). Using a mean age of 1.2 Ma yields an expected recurrence rate of approximately 7 v/my. However, the ages of Crater Flat volcanoes are currently estimated at 1.2±0.4 Ma. Using the upper and lower bounds of this uncertainty, the expected recurrence rate is between approximately 4.5 and 10 v/my. The repose-time method has distinct advantages over techniques that average over an arbitrary period of time because it restricts the analysis to a time period that is meaningful in terms of volcanic activity. In this sense it is similar to methods applied previously to estimate time-dependent relationships in active volcanic fields.[16] However, because the method depends on the age of the oldest event, uncertainty in volcano ages has a greater effect. In this case, the result is the recurrence rate is known only to within approximately 7±3 v/my.

Ho[12] applied a Weibull-Poisson technique[17] to estimate the recurrence rate of new volcano formation in the YMR as a function of time. Ho[12] estimates $\lambda(t)$ as:

$$\lambda(t) = \left(\frac{\beta}{\theta}\right)\left(\frac{t}{\theta}\right)^{\beta-1} \qquad (2)$$

where t is the total time interval under consideration (such as the Quaternary), and β and θ are intensity parameters in the Weibull distribution that depend on the frequency of new volcano formation within the time period, t, and the change in

Table 1. Locations of volcanic centers and ages used for statistical models.[1-5] Vent coordinates in Universal Transverse Mercator, zone 11, Clarke 1866 spheroid.

Name	Age (Ma)	UTM easting	UTM northing	Name	Age (Ma)	UTM easting	UTM northing
Amargosa Valley SW	≈4.4	543376	4048820	Hidden Cone	0.3±0.2	523301	4113698
Amargosa Valley	≈4.4	544817	4050859	Thirsty Mesa	≈4.5	528129	4112249
Amargosa Valley NE	4.4	550306	4053139	Rocket Wash	8.0±0.2	535539	4109028
Lathrop Wells	0.10±0.05	543737	4060073	Buckboard Mesa	2.8±0.1	554946	4109111
Crater Flat S	4.0±0.5	541493	4066057	Pahute Mesa W	10.4±0.4	548758	4133489
Crater Flat E	4.0±0.5	543704	4067644	Pahute Mesa	9.1±0.7	554170	4134467
Crater Flat W	4.0±0.5	540584	4067787	Pahute Mesa E	8.8±0.1	561927	4132182
Crater Flat NW	4.0±0.5	539915	4070959	Paiute Ridge S	8.5±0.3	593698	4101888
Crater Flat W	4.0±0.5	536879	4068573	Paiute Ridge N	8.5±0.3	593611	4103166
Little Cone SW	1.2±0.4	534626	4069423	Scarp Canyon	8.7±0.3	595625	4103906
Little Cone NE	1.2±0.4	534825	4069884	Nye Canyon N	6.8±0.3	603210	4091744
Red Cone	1.2±0.4	537259	4071648	Nye Canyon	6.8±0.3	602370	4085671
Black Cone	1.2±0.4	538257	4074275	Nye Canyon SE	6.8±0.3	600999	4082470
Northern Cone	1.2±0.4	540088	4079455	Nye Canyon SW	6.8±0.2	599557	4083139
Little Black Peak	0.3±0.2	521298	4111346				

Table 2. Dependence of the Weibull-Poisson model of recurrence rate of volcano formation on age.

Volcano Age Estimates	t(m.y.)	β	θ	λ(v/my) (90% Confidence Interval)	P[10,000 yr]
mean ages[1]	1.6	1.1	0.2	5.4 (1.8, 12.4)	5%
oldest ages[2]	1.6	0.3	0.001	1.5 (0.5, 3.44)	1.5%
youngest ages[3]	1.6	2.2	0.6	11.0 (3.7, 25.3)	10%
mean ages[1]	1.2	0.3	0.002	2.1 (0.7, 4.8)	2%
varying ages[4]	1.2	0.7	0.2	4.8 (1.6, 11.0)	5%

[1] Volcanoes are assumed to have the mean ages reported in Table 1. For example, an age of 1.2 m.y. is used for Black Cone.
[2] Volcanoes are assumed to have the oldest ages reported in Table 1. For example, an age of 1.6 m.y. is assumed for Black Cone.
[3] Volcanoes are assumed to have the youngest ages reported in Table 1. For example, an age of 0.8 m.y. is assumed for Black Cone.
[4] Crater Flat volcanoes are assumed to vary in age between 1.2 and 0.8 m.y.

frequency during t. In a time-truncated series, β and θ are estimated from the distribution of past events. In this case there are $n = 8$ new volcanoes formed in the YMR during the Quaternary. β and θ are given by:[12]

$$\beta = \frac{n}{\sum_{i=1}^{n} \ln\left(\frac{t}{t_i}\right)} \quad (3)$$

and

$$\theta = \frac{t}{n^{1/\beta}} \quad (4)$$

where t_i refers to the time of formation of the i^{th} volcano. If β is approximately equal to unity, there is little or no change in the recurrence rate as a function of time and a homogeneous Poisson model would provide an estimate of regional recurrence rate quite similar to the nonhomogeneous Weibull-Poisson model. If $\beta > 1$ then a time trend exists in the recurrence rate and volcanoes form more frequently with time (i.e., waxing). If $\beta < 1$, new volcanoes form less frequently over time (i.e., waning).

Where few data are available, such as for volcanism in the YMR, the value of β can be strongly dependent on the period t and the timing of individual eruptions. Ho[12] analyzed volcanism from 6 Ma, 3.7 Ma, and 1.6 Ma to the present and concluded that volcanism is developing in the YMR on time scales of $t = 6$ Ma and 3.7 Ma, and has been relatively steady ($\beta = 1.1$) during the Quaternary.

Uncertainty in the ages of Quaternary volcanoes has a strong impact on recurrence rate estimates calculated using a Weibull-Poisson model. For example, if mean ages of Quaternary volcanoes are used (Table 1) and $t = 1.6$ Ma then, as Ho[12] calculated, $\beta = 1.1$ and the probability of a new volcano forming in the region within the next 10,000 yr is approximately 5%. This agrees well with recurrence rate calculations based on simply averaging the number of new volcanoes that have formed since 1.6 Ma. However, if older volcano ages are used (i.e., Crater Flat volcanoes are 1.6 Ma) then $\beta = 0.3$ and the magmatic system appears to be waning. Using these parameters, the probability of a new volcano forming during a 10,000 yr confinement period is approximately 1.5% (Table 2). Conversely, if the Crater Flat volcanoes are only 0.8 Ma, the magmatic system appears to be waxing ($\beta = 2.2$) and the probability of a new volcano forming within 10,000 yr is approximately 10%. Therefore, given the uncertainty in the ages of Quaternary volcanoes in the YMR, it is currently not possible to differentiate between waxing and waning models for the frequency of new volcano formation using the Weibull-Poisson method over a constant time period, $t = 1.6$ Ma.

B. M. Crowe (written communication, 1993) has pointed out that the Weibull-Poisson model is strongly dependent on the value of t, and suggested that t should be limited to the time since the initiation of a particular episode of volcanic activity. This has an important effect on Weibull-Poisson probability models. If mean ages of Quaternary volcanoes are used and $t = 1.2$ Ma, the probability of a new volcano forming in the next 10,000 years drops from 5% to 2% and $\beta < 1$, indicating waning activity (Table 2). Alternatively, volcanism along the Crater Flat volcano alignment may have occurred over a period of several hundred thousand years.[18] If volcanism was initiated along the alignment at approximately 1.2 Ma but continued through 0.8 Ma, the expected recurrence rate is again close to 5 v/my and the probability of new volcanism in the YMR within the next 10,000 yr is about 5% ($t = 1.2$ Ma, Table 2). The confidence intervals calculated on λ(t) are quite large (Table 2) in all of these examples due to the few events ($n=8$) on which the calculations are based. Using the youngest volcano ages for example, the recurrence rate can only be constrained to less than 25 v/my with 90% confidence. Using mean ages, the recurrence rate is less than 12 v/my with 90 percent confidence (Table 2).

These calculations indicate that a broad range of expected regional recurrence rates should be considered in probability models primarily because of the few number of volcanic eruptions in the Quaternary and the relatively large uncertainty in the ages of these eruptions. Given this uncertainty, we adopt an estimate of 7±3 v/my for the YMR.

with the understanding that additional high-precision dates may make it necessary to revise this estimate and that, currently, the 90% confidence envelops for Weibull-Poisson recurrence rate distributions encompass a broader range of recurrence rates than are reflected in this estimate.

ESTIMATING SPATIAL VARIATION IN RECURRENCE RATE

Several models assessing the probability of future volcanic events in the YMR and the likelihood of a repository-disrupting event rely on the assumption that Plio-Quaternary vents have been emplaced in a completely spatially random (CSR) distribution over some bounded area.[4,14-15] The assumption of a CSR, or spatially homogeneous Poisson distribution,[19] of volcanoes does not seem appropriate because vents in the YMR appear to cluster, forming temporal and spatial patterns[15,20] (Figure 1). This clustering is consistent with cinder cone clustering observed in other volcanic fields.[21-25] Sheridan[20] suggests that one method of accounting for spatial heterogeneity in vent distribution is to assume that post 4.5-Ma vents in Crater Flat system are formed as a result of steady-state activity, and that the dispersion of these vents represents two standard deviations on an elliptical Gaussian probability surface. Using this assumption, Sheridan[20] modeled the probability of repository disruption by Monte Carlo simulation for both volcanic events and dike intrusions, noting that variations in the shape of the probability surface significantly alter the probability of igneous disruption of the HLW repository. An alternative approach has been to define specific areas in which the recurrence rate of igneous events is increased. For example, Smith et al.[26] and Ho[11] define narrow NNE -trending zones within which average recurrence rate exceeds that of the surrounding region. These zones correspond to cinder cone alignment orientations that are presumably controlled by crustal structures.[11,26]

Here, we apply two statistical tests to evaluate the null hypothesis that vents in the YMR are well described as CSR. One such test is the Clark-Evans, *CE*, test,[27] which compares the mean distance between nearest-neighbor observations, d, for n volcanoes within an area, A, against the mean distance, δ, expected from randomly distributed points within the same area:

$$CE = \frac{d - \delta}{s_e} \tag{5}$$

Assuming a spatially homogeneous Poisson distribution:[28]

$$\delta = 0.5\sqrt{A/n}$$

and

$$s_e = \sqrt{\frac{0.0683A}{n^2}}$$

where s_e is the standard error. Applying the Clark-Evans test using all volcanoes within the AMRV (Figure 1 and Table 1), $n = 19$ volcanoes, $A = 1900$ km^2, $d = 4200$ m, $\delta = 5000$ m, and $CE = -1.3$. Testing CE against a normal distribution rejects the null hypothesis at the 90% confidence level. Applying the test only to Quaternary volcanoes in the AMRV rejects the null hypothesis at a lower confidence level of 84%. However, the Clark-Evans test is not always robust because of edge effects.[27-29] In the YMR, for example, the ability to distinguish vent clusters from a CSR vent distribution is strongly dependent on the size and shape of the area considered. The AMRV is a minimum area bounding all volcanoes in the YMR less than ≈4.5 Ma (Figure 1). It is less likely that the Clark-Evans test will identify clusters within this area than in a slightly larger area.

More recently, near-neighbor statistics have been developed to test for CSR distributions in point patterns (i.e., volcano distributions). Aherne and Diggle[30] define two measures of intensity (expected number of vents/unit area):

$$\lambda_p = \frac{m}{\sum_{i=1}^{m} u_i} \tag{6a}$$

$$\lambda_v = \frac{m}{\sum_{i=1}^{m} v_i} \tag{6b}$$

where u_i and v_i are areas of circles whose radii are the distance from the i^{th} randomly chosen point to the nearest volcano, and the i^{th} volcano to its nearest neighbor, respectively; m is the number of near neighbors; λ_p is the intensity estimated from m point-to-volcano measurements; and λ_v is the intensity estimated from m volcano-to-volcano measurements. For a CSR distribution, λ_p and λ_v should be approximately equal. In clustered distributions, λ_v tends to measure the intensity within clusters, and λ_p is a measure of cluster intensity.[28] The Hopkins F-test provides a method of testing for randomness in the vent pattern given these two measures of intensity:

$$Hop_F = \frac{\lambda_p}{\lambda_v} \tag{7}$$

The Hopkins F-test has a $F(2m,2m)$ distribution.[31] Following Aherne and Diggle,[30] random points within the AMRV are used to calculate λ_p. Considering all volcanoes in the AMRV: $\lambda_v = 3.85 \times 10^{-3}$ volcanoes/km^2, $\lambda_p = 9.31 \times 10^{-3}$ volcanoes/km^2, and $Hop_F = 2.42$. Considering only Quaternary volcanoes, $Hop_F = 3.14$. In either case, the null hypothesis that volcanoes are randomly distributed in the AMRV is rejected with greater than 99% confidence. Even in areas as narrowly defined as the CFVZ (Figure 1), the Hopkins F-test demonstrates with greater than 95% confidence that volcano distribution is not appropriately modeled as a CSR distribution. Using a paired Student t-test at a 99% confidence interval, the differences in ages of near-neighbor cinder cones is less than expected given a random distribution of ages, indicating that cinder cone clusters are temporally as well as spatially distinct.

Expected recurrence rate per unit area at an arbitrary point within the YMR also can be estimated using varying numbers of near neighbors:

$$\lambda_r = \frac{m}{\sum_{i=1}^{m} u_i t_i} \tag{8}$$

where near-neighbor volcanoes are determined as the minimum of $u_i t_i$, and t_i is the time elapsed since the formation of the i^{th} near-neighbor volcano and u_i is defined as before, with $u_i \geq 1$ km^2. We differentiate between various near-neighbor nonhomogeneous Poisson models by comparing the observed recurrence rate for the region with the expected regional recurrence rate calculated using near-neighbor methods, defined by:

$$\lambda_t = \iint_{X\,Y} \lambda_r(x,y)\,dy\,dx \qquad (9)$$

where λ_t is the estimated YMR recurrence rate, based on the nonhomogeneous model. In practice, recurrence rates, λ_r, are calculated on a grid and these values are summed over the region of interest:

$$\lambda_t = \sum_{i=0}^{m}\sum_{j=0}^{n} \lambda_r(i,j)\,\Delta x \Delta y \qquad (10)$$

where Δx and Δy are 2000 m, the grid spacing used in the calculations, and m and n are the number of grid points used in the X and Y directions, respectively. The dependence of expected regional recurrence rate, λ_t, on the number of near-neighbor volcanoes, m, used in the calculation is illustrated in Figure 2. The relationship between the number of near-neighbor volcanoes and regional recurrence rate depends on the ages of the volcanoes (equation 8), which are known with varying precision. Consequently, equation 10 is used to calculate regional recurrence rates using mean volcano ages, and the youngest and oldest ages for each volcano (Table 1) based on reported uncertainties in ages.[4-6,32] Nonhomogeneous Poisson models using six to seven near-neighbor volcanoes give regional recurrence rates of 7±3 v/my (Figure 2).

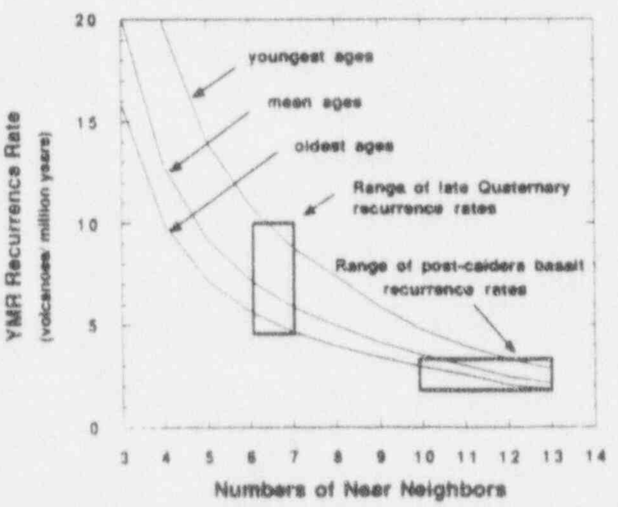

Figure 2: Recurrence rate for the formation of new volcanoes in the YMR is estimated using a number of near-neighbor nonhomogeneous Poisson models. Curves are calculated using mean volcano ages, oldest estimated ages, and youngest estimated ages (Table 1). Comparison with recurrence rates estimated directly from geochronological data indicates that six and seven near-neighbor models most closely approximate Quaternary recurrence rates; ten to thirteen near-neighbor models most closely approximate post-caldera basalt recurrence rates.

PROBABILITY MODELS

The probability of volcanic disruption of the candidate repository site can be estimated assuming a nonhomogeneous Poisson distribution

$$P[N(t) \geq 1)] = 1 - exp\left[-t\iint_{X\,Y} \lambda_r(x,y)\,dy\,dx\right] \qquad (11)$$

where the limits of integration define the area of the repository. This relation is closely approximated in discretized form:

$$P[N(t) \geq 1] = 1 - exp\left[-t\sum_{a} \lambda_r \Delta x \Delta y\right] \qquad (12)$$

where Δx and Δy each are one kilometer and a is the approximate total area of the repository. These probabilities are very close to the probability of one volcanic event because the probability of two or more events is vanishingly small ($\approx 1\times10^{-9}$). The probabilities of volcanic disruption of the repository using a range of near-neighbor models are given in Figure 3. The probability of disruption also is determined for various repository areas calculated using mean volcano ages (Figure 4). The area of the HLW repository is currently estimated to be approximately 6 km^2. Larger areas (i.e., 8 to 10 km^2) are presented to indicate the effects of an increase in repository size, and more importantly, to account for the area affected by the emplacement of a new volcanic center. Scoria mounds and related satellite vents at Red Cone, Black Cone, and Lathrop Wells[26,33] extend for at least 0.5 km around the main vent, which indicates that establishing a new volcanic center within roughly 0.5 km of the repository may result in direct disruption of the HLW repository. An area of 8 to 10

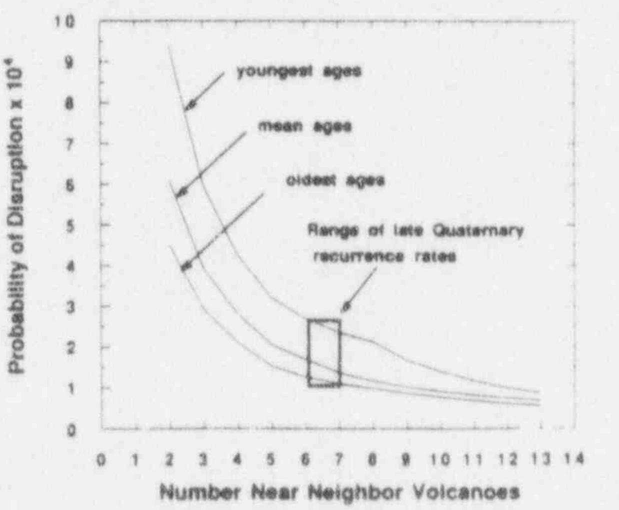

Figure 3: Estimated probability of disruption of the HLW repository varies with the number of near neighbors used in nonhomogeneous Poisson models and with the uncertainty in the ages of Quaternary YMR cinder cones (Table 1). Calculations are made for the probability of a volcano forming within an 8 km^2 block at the candidate repository site (Figure 1) during the next 10,000 years. Six to seven near-neighbor models most closely approximate a Quaternary recurrence rate of 7±3 v/my. Ten to thirteen near-neighbor models most closely approximate a post-caldera basalt recurrence rate of 3 v/my.

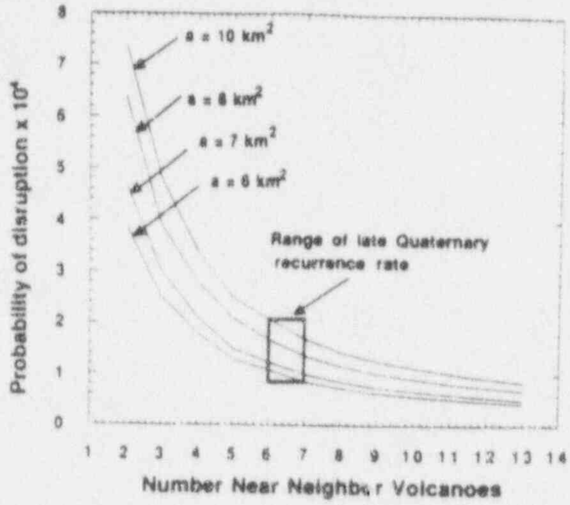

Figure 4: Estimated probability of a volcano forming at the repository site (Figure 1) increases with increasing area of the site. Magma erupting at main vents located outside the repository perimeter may disrupt the repository, as cinder cones in the region often have satellite vents that extend to 0.5 km. Larger area calculations (e.g., $a = 10$ km^2) account for the probability of disruption by vents centered within 0.5 km of the repository. Calculations are made using mean volcano ages (Table 1) and indicate the probability of disruption during the next 10,000 years. Six to seven near-neighbor models most closely approximate the Quaternary recurrence rate. Ten to thirteen near-neighbor models most closely approximate the post-caldera basalt recurrence rate.

km^2, therefore, may more accurately reflect the area within which a new volcanic center could form and disrupt the HLW repository. Using an 8 km^2 area in equation 12, the probability of disruption during a 10,000 year confining period is between 1.4×10^{-4} and 1.7×10^{-4} for a mean late-Quaternary recurrence rate (six to seven near-neighbors) and 6.9×10^{-5} to 9.2×10^{-5} for a post-caldera basalt recurrence rate (ten to thirteen near-neighbors). Using a range of Quaternary rates (7±3 v/my) and an 8 km^2 area, the probability of disruption is between 1.1×10^{-4} and 2.7×10^{-4}. For a larger area ($a = 10$ km^2) and using young volcano ages, the probability of volcanic disruption in 10,000 years increases to 3.4×10^{-4}. Conversely, using the oldest ages for volcanoes and a smaller area, $a = 6$ km^2, the probability of disruption is 8.0×10^{-5}. Based on the nonhomogeneous Poisson models for various Quaternary recurrence rates and areas, most estimates of the probability of repository disruption are between 1×10^{-4} and 3×10^{-4} for the next 10,000 years (Figures 3 and 4).

One way to illustrate spatial variation in estimated recurrence rate for the YMR, and hence the probability of disruptive volcanic events, is to map probabilities calculated from nonhomogeneous Poisson models. Applying equation 8, the expected recurrence rate is estimated at points on a grid (grid node spacing 2 km) using different numbers of near-neighbors. Probabilities of at least one event occurring within one repository area (8 km^2) about each grid point during the next 10,000 years are then calculated (equation 12). Two such maps are illustrated in Figures 5a and 5b, generated using six and eleven near-neighbors, respectively. The tendency for vents to cluster is well illustrated by the $m = 6$ near-neighbors

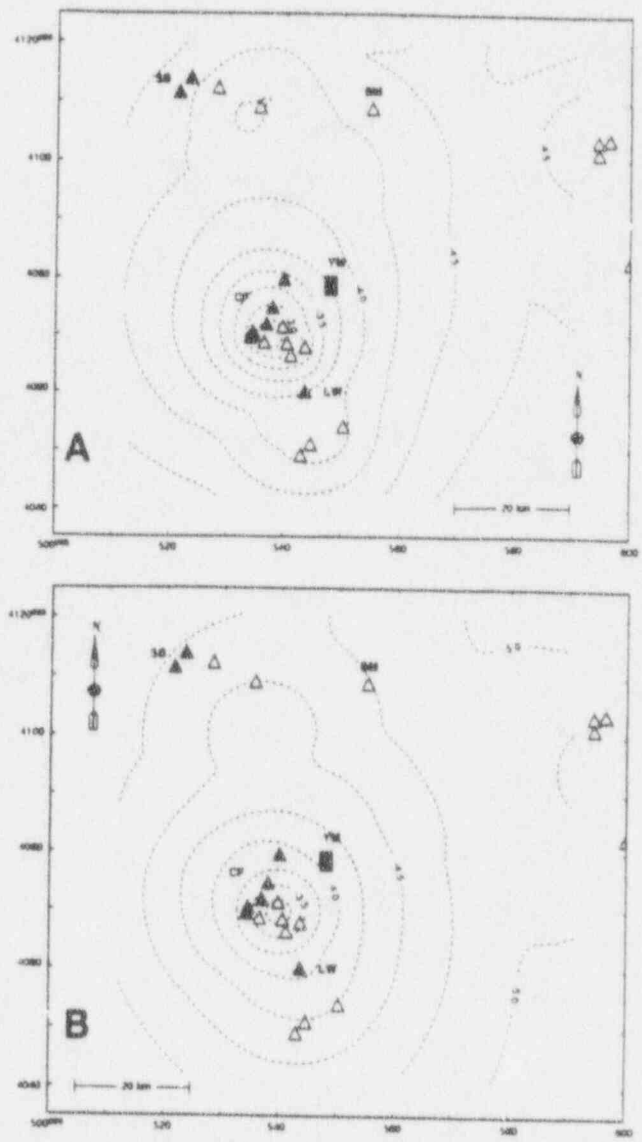

Figure 5: Probability of a new volcano forming during the next 10,000 years varies in the YMR because of the tendency for volcanoes to cluster. Here the logarithm of probability of a volcano forming within a 8 km^2 area during the next 10,000 years is contoured using 6 near-neighbor (a) and 11 near-neighbor (b) nonhomogeneous Poisson models. These models reflect Quaternary and post-caldera basalt recurrence rates, respectively. Both models indicate that the probability of disruption of the proposed repository (solid rectangle) is higher than in the YMR as a whole due to the relative proximity of the site to Quaternary Crater Flat volcanoes. Solid triangles are Quaternary volcanoes, open triangles are Neogene vents, YM - Yucca Mountain repository, CF - Crater Flat, SB - the Sleeping Butte volcanoes (Little Black Peak and Hidden Cone), BM - Buckboard Mesa, and LW - Lathrop Wells (Table 1). The contour interval is 0.25 log(P[N≥1, 10,000 yr]) (e.g., -4 is a probability of 1×10^{-4} of a new volcano forming within an 8 km^2 area in 10,000 years). Across the YMR, probabilities vary from more than 1×10^{-3} in Crater Flat Valley (Figure 5a) to less than 1×10^{-5}. Map coordinates are in Universal Transverse Mercator, Clarke 1866 projection.

probability map. On this map (Figure 5a), the probability of renewed volcanic activity is highest in Crater Flat. South of Red Cone, for example, the probability of a new volcanic center forming in the next 10,000 years within an 8 km^2 area is between 1.6×10^{-3} and 2.0×10^{-3} for a mean Quaternary recurrence rate (i.e., six to seven near-neighbors) and between 2.0×10^{-4} and 8.0×10^{-4} for a post-caldera basalt recurrence rate (i.e., ten to thirteen near-neighbors). Probability contours are elongate in a N-S direction, reflecting the overall distribution of Quaternary cones. Although the probability of disruption is less using an $m = 11$ near-neighbor model (Figure 5b), the Crater Flat cluster persists as an area of high probability on this plot and probability contours remain elongate in a N-S direction. In all cases, the probability of volcanic disruption of the proposed HLW repository is high compared with most homogeneous Poisson models[4,14-15] because the repository site is relatively close to the largest cluster of young volcanoes in the YMR.

SUMMARY OF PROBABILITY ANALYSIS

Probability models based on the assumption of complete spatial randomness will overestimate the likelihood of future igneous activity in parts of the YMR far from Quaternary centers and underestimate the likelihood of future igneous activity within and close to Quaternary volcano clusters (Figures 5a and 5b). This has a profound influence on probability calculations for future igneous activity near the candidate HLW repository, because the site is located comparatively close to Crater Flat, the largest cluster of young volcanoes in the YMR (Figure 1). Vent clustering in the YMR is statistically significant, and robust probability models should account for this clustering. Nonhomogeneous Poisson probability models calculated by near-neighbor methods can be used to estimate the probability of volcanic disruption of the candidate HLW repository. Assuming a Quaternary recurrence rate of 7±3 v/my , these models estimate a probability of disruption between 8.0×10^{-5} and 3.4×10^{-4} in 10,000 years, with most estimates between 1×10^{-4} and 3×10^{-4}. The candidate HLW repository site is positioned on a probability gradient. West of the proposed site, the probability of volcanism within the next 10,000 years increases substantially due to the presence of Quaternary volcanoes in Crater Flat. The probability of volcanism within the next 10,000 years decreases east of the proposed repository site. Further refinement of probability models will likely alter these estimates, and they are not intended to represent a complete analysis of the probability of repository disruption by igneous activity. The proposed nonhomogeneous model takes into account one important geological feature of volcanic fields: centers tend to cluster within these fields through time. Additional geological information, such as the impact of pre-existing structure[26] or strain rate on volcanism, will need to be fully taken into account before a more refined assessment of the probability of future volcanic activity in the YMR can be made with confidence.

ACKNOWLEDGMENTS

Budhi Sagar, William M. Murphy, Gerry L. Stirewalt, and Kenneth D. Mahrer provided comprehensive reviews of this work. This manuscript was prepared to document work performed at the Center for Nuclear Waste Regulatory Analyses (CNWRA) for the U.S. Nuclear Regulatory Commission (NRC) under Contract No. NRC-02-88-005. The activities reported herein were performed on behalf of the NRC Office of Nuclear Regulatory Research. This report is an independent product of the CNWRA and does not necessarily reflect the views or regulatory position of the NRC.

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